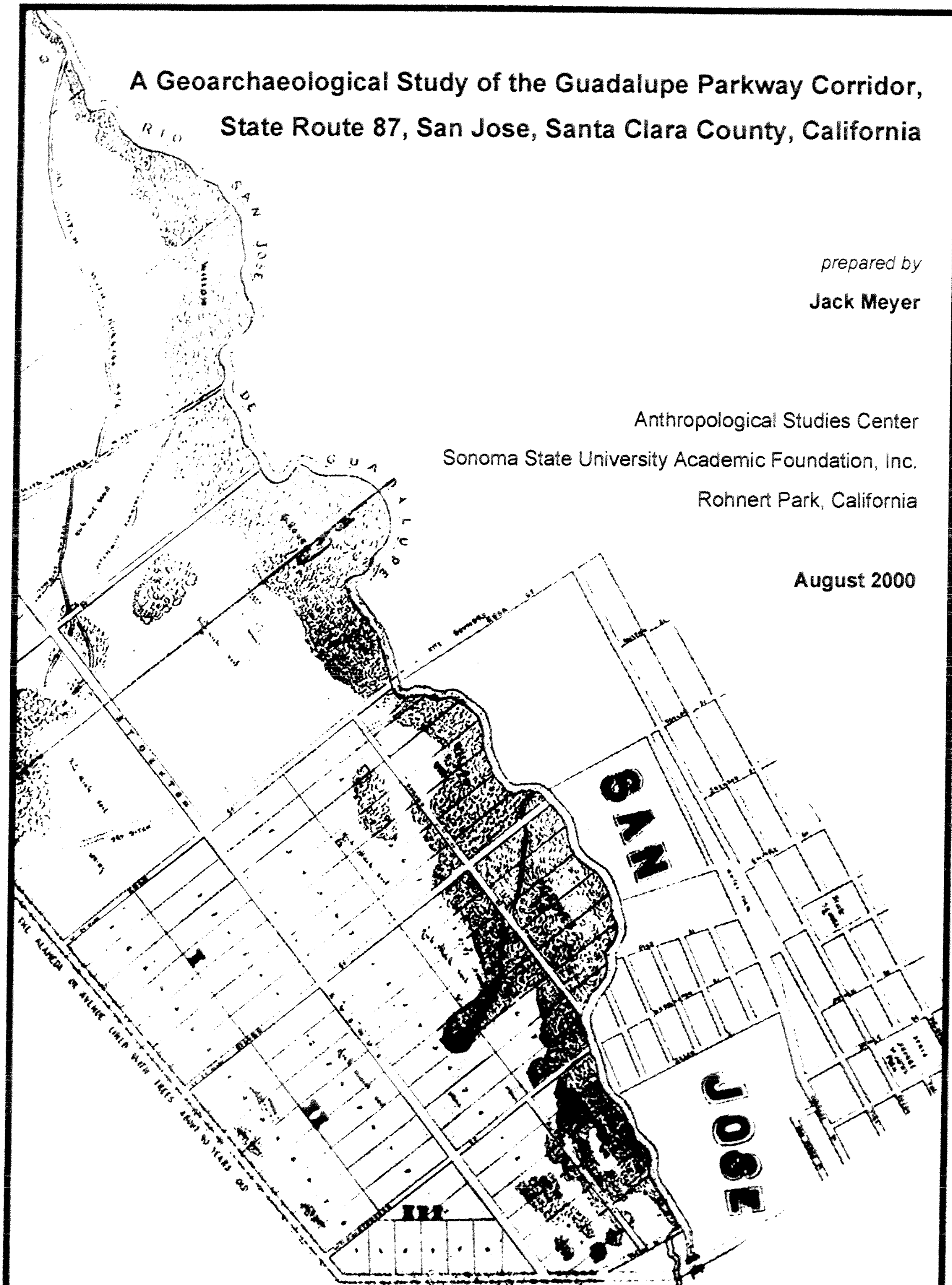
A Geoarchaeological Study of the Guadalupe Parkway Corridor, State Route 87, San Jose, Santa Clara County, California



prepared by

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Sonoma State University Academic Foundation, Inc.

Rohnert Park, California

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Front Cover Image

a portion of

1850

Plan of the Alameda Gardens

within the Adjoining City of San Jose,

originally known as *El Potrero de Santa Clara*

(from Spearman 1963:114)

NOTE

The contents of this report reflect the views of the authors, who are responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the State of California. This report does not constitute a standard, specification, or regulation.

SUMMARY OF FINDINGS

At the request of the California Department of Transportation (Caltrans), a geoarchaeological study was conducted for the proposed Route 87 Guadalupe Parkway Upgrade project. This document reports the findings of that study which was designed to: (1) identify and document the natural landform-deposits; (2) search for potentially buried archaeological materials; and (3) evaluate the potential for buried archaeological sites in the project area. The study included archival research, subsurface field exploration, flotation, pollen, and radiocarbon dating analyses.

The Route 87 Project is being conducted in compliance with Section 106 of the National Historic Preservation Act of 1966 as amended, which requires agencies to take into account the effects of their undertakings on historical properties when using either federal funds or permits. Project plans call for a 3.25 mile segment of Route 87 (Guadalupe Parkway), located between Highway 101 and Interstate 280, to be converted from four-lanes to six-lanes. This segment of Route 87 is located in downtown San Jose along the eastside of the Guadalupe River. The project will require a variety of large earth-disturbing activities, that may adversely impact archaeological resources that are potentially buried or otherwise unidentified.

An initial sensitivity assessment was conducted to evaluate the potential to encounter buried archaeological deposits in the project corridor (Allen et al. 1999). The assessment found that most of the natural landform-deposits at the surface of the project area are composed of alluvium that is Middle Holocene-age or younger. Based on this finding, it was determined that: (1) most buried sites occur where alluvial soils are mapped at the surface, and (2) that the chance of encountering a buried site is greatest in areas where alluvial landforms overlie basin landforms. Using these and other distinctions, large segments of the project corridor were estimated to have a moderate to high potential for buried archaeological resources. Consequently, geoarchaeological explorations were recommended for those segments. The assessment recommended the use of a geoarchaeological landscape approach to reduce the area and/or volume of deposits to be searched and/or monitored, and thereby, increase the likelihood that potentially buried archaeological resources would be identified.

The current study found that the project area contains a sufficient quantity and variety of data for addressing the important research issue of human occupation and landscape evolution. The results of this study indicate that the project area is composed of multiple landform-deposits that were formed by alternating cycles of deposition and relative landform stability. The nature and extent of these deposits indicates that: (1) basin landforms are generally distributed to the west of the river; (2) alluvial floodplain landforms are distributed to the east of the river; and (3) landforms associated with active channels are distributed along the river. These landform-deposits yielded a variety of datable materials including bone, shell, charcoal, and soil humates. Radiocarbon dates obtained from alluvium and buried soils (paleosols) indicate that periods of floodplain stability were repeatedly interrupted by depositional episodes over the past 16,000 years. A comparison of stratigraphic sequences reveals that there may be considerable variability in the age of different landform-deposits within the project area. Thus, the project area was found to contain distinctive Holocene-age landform-deposits that were traced laterally in search of buried archaeological sites. As a result, two buried prehistoric archaeological deposits were discovered.

Evidence of paleoenvironmental conditions in the project area include: (1) alluvial stratigraphic sequences that indicate alternating cycles of landform stability and instability; (2) carbon isotope (13C/12C) ratios that are a proxy indicator of vegetation and climate; (3) a few pollen grains as an indicator of general vegetation communities; and (4) the presence of charred plant remains as an indicator of specific plant types. This evidence indicates that: (1) conditions may have been warmer

and/or drier during the Late Pleistocene than today; (2) a period of prolonged floodplain stability occurred during the Early Holocene; (3) increased channel aggradation, widespread floodplain deposition, and shorter periods of land stability occurred during the Middle and Late Holocene-age, and (4) rapid channel aggradation and levee building occurred along the banks of the Guadalupe during the past few hundred years. This evidence suggests that the project area has undergone a series of paleoenvironmental changes that altered the landscape, and likely affected human settlement and subsistence activities. As such, the findings represent a significant advance in our understanding the nature, timing, and extent of past environmental conditions that may have influenced human use and/or occupation of the project area.

This study demonstrates that landscape evolution has exerted a strong influence on the visibility of the archaeological record in the project area, confirming that the APE possesses considerable potential for containing buried prehistoric archaeological resources. Thus, the apparent presence or absence of surface sites in the project area is by no means a full reflection of prehistoric human population and/or settlement patterns. Instead, accurate interpretation of these patterns will require that the influence of both natural and cultural processes be evaluated in terms of differential landscape evolution over time. Archaeological monitoring is recommended for those portions of the project corridor where earth disturbing activities are planned. It is also recommended that future archaeological studies in the area consider the potential effects of landscape changes on the visibility of archaeological deposits and the nature and completeness of the archaeological record in the Guadalupe River floodplain.

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INTRODUCTION

At the request of the California Department of Transportation (Caltrans), a geoarchaeological study was conducted for the proposed Guadalupe Parkway Upgrade project. This document reports the findings of that study, which included archival research, subsurface field exploration, and flotation, pollen, and radiocarbon dating analyses. Project plans call for a 3.25 mile segment of State Route 87 (Guadalupe Parkway), located between Highway 101 and Interstate 280, to be converted from four-lanes to six-lanes. This segment of Route 87 is located in downtown San Jose along the eastside of the Guadalupe River (Figure 1). The project will require a variety of large earth-disturbing activities, including: (1) the excavation of four water detention basins; (2) the placement of pilings for wider bridges at four locations; (3) the excavation and contouring of Route 87 below grade at Taylor Street; and (4) the excavation and removal of about 4.5 square acres from the east bank of the Guadalupe River for riparian mitigation. Given the nature and extent of proposed construction, it was determined that the project activities may adversely impact archaeological resources that are potentially buried or otherwise unidentified (Allen et al. 1999).

Regulatory Context

The project is being conducted in compliance with Section 106 of the National Historic Preservation Act of 1966 as amended, which requires agencies to take into account the effect of their undertakings on historical properties when using either federal funds or permits. The Federal Highway Administration (FWHA) was designated as the lead federal agency for the project; however, Caltrans is responsible for the research, identification, and evaluation of any historic properties. This study was implemented as part of Caltrans responsibility "... to make a reasonable and good faith effort to identify historic properties that may be affected by an undertaking" (36 CFR 800.4(b)). Further details regarding the project's regulatory context, proposed impacts, and Area of Potential Effect (APE) are described in *Upgrade of the Guadalupe Parkway, San Jose: Historic Properties Treatment Plan* (HPTP) by Allen et al. (1999).

NATURAL CONTEXT

Project Setting

The project area is situated in the northern Santa Clara Valley within a broad, nearly level floodplain that borders the Guadalupe River (Figure 1). The river is fed by a number of tributaries that originate in the Santa Cruz Mountains, west of the Santa Clara Valley. The river's drainage basin is the third largest (380 km2 or 147 miles2) in the south Bay area, next to Coyote Creek (910 km2) and Alameda Creek (1,700 km2) (Fio and Leighton 1995). Guadalupe Creek becomes the Guadalupe River at its confluence with Alimitos Creek. One of the river's major tributaries, Los Gatos Creek, joins the main channel at a confluence near Santa Clara Street, just south of the project area. The river flows north from San Jose towards the city of Alviso where it enters San Francisco Bay.

Paleoenvironment

The San Francisco Bay area has undergone a series of significant environmental changes since prehistoric people may have first inhabited the region. Studies suggest that climatically induced environmental fluctuations, such as Holocene sea-level rise, were responsible for large-scale landscape changes in the Bay area (Atwater 1979, Atwater et al. 1979; Atwater, Hedel, and Helley 1977; Borchardt 1992; Koltermann and Gorelick 1992; Meyer 1996; Meyer and Rosenthal 1997; Rogers 1988). These changes undoubtedly influenced the distribution of plant, animal, and human communities in and around the Bay (Atwater et al. 1979), and affected the preservation and visibility of the region's archaeological record (Bickel 1978a, 1978b).

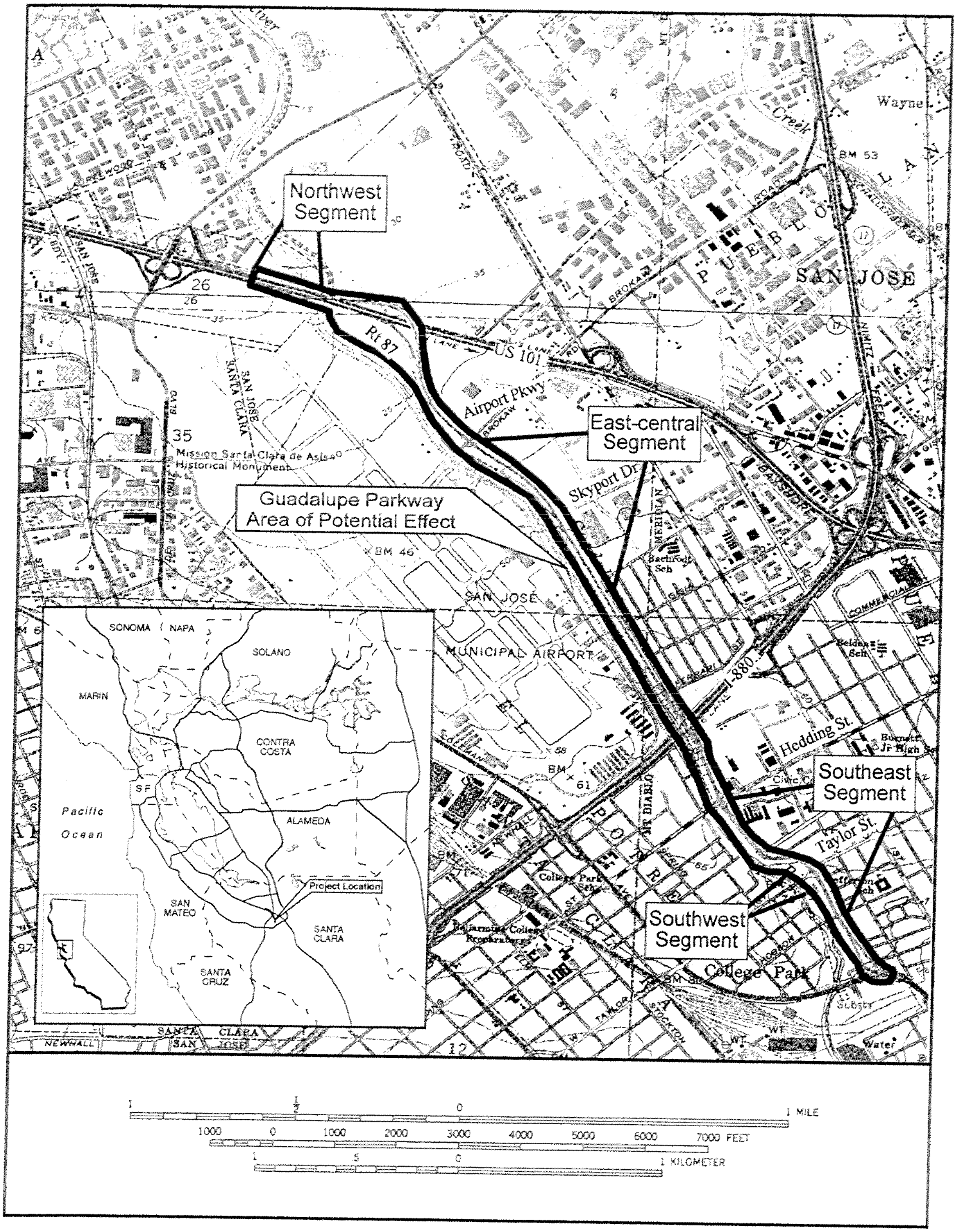


FIGURE 1. Location of Project Area, Area of Potential Effect (APE), and Study Segments

It has been suggested that the northern Santa Clara Valley experienced a "climax environment" during the Upper Archaic period (~2,000 year ago) that was interrupted or "degraded" by extensive alluvial deposition ("siltation") during the latter part of the Upper Archaic and Emergent periods (Anastasio 1988:403). It was hypothesized that the apparent abandonment and/or relocation of many Upper Archaic period sites around 1,500 years ago may be related to these "climatic events or changes" (Cartier 1988:280). These changes may have been accompanied by a significant decline in native oyster populations and the development of an extensive depositional unconformity in sediments within the bay (see Allen et al. 1999:131-132).

Such large-scale paleoenvironmental changes may have initiated episodes of widespread alluvial deposition that could have buried prehistoric sites on the Guadalupe River floodplain. Changes of such magnitude may have also been responsible for significant fluctuations in the availability and/or productivity of particular resources, which lead to major transitions in the pattern of human settlement and/or subsistence activities. As such, the subject of paleoenvironmental change was identified as an important research issue for archaeological studies in the project area (Allen et al. 1999). A detailed overview of the timing and magnitude of paleoenvironmental change (i.e., landscape evolution, bay/estuary development) in the Bay area, and the possible effects on prehistoric human settlement and subsistence (resource availability) are provided in the HPTP (Allen et al. 1999).

Alluvial Geology

Geological maps indicate that surface deposits in the project area are composed of Holocene-age alluvium that is generally less than 11,000 years old. These deposits have been variously described as "younger alluvial fan deposits" (Helley and Brabb 1971), "medium-grained alluvium" (Helley et al. 1979), and simply "alluvium" (Wagner, Bortugno, and McJunkin 1990). These maps indicate the general age and extent of the surface deposits, but they do not identify areas of older or younger deposits within the Holocene alluvium, nor do they indicate the age or extent of subsurface deposits. While a few radiocarbon dates are associated with these deposits (Meade 1967:C41; Price 1981), their actual age has not been determined. A more recent geological map of the area divides the Holocene deposits into "floodbasin, floodplain, and natural levee" deposits, in order of decreasing age (Helley et al. 1994). As shown in Figure 2, the floodbasin deposits are located west of the Guadalupe River, the floodplain deposits are located east of the river, and the natural levee deposits are located along both sides of the present river course.

Landforms that exhibit clear evidence of soil formation (addition of dark organic matter; accumulation of illuvial clays and/or carbonates; advanced oxidation or mottling) are expected to have a higher potential for containing buried archaeological resources than deposits that lack evidence of soil formation. Deposits composed of sorted sand and gravel are expected to have little potential for containing intact archaeological resources, however, such deposits may indicate the presence of stream channels that could be associated prehistoric human use.

Soil and Sediments

Gardner et al. (1958) and Weir and Storie (1947) mapped the soil types at the surface of the project area. Both studies indicate the occurrence of two primary soil types ("basin" and "alluvial") throughout most of the project area, with only minor variations in the horizontal distribution of these types based on textural characteristics and/or soil profile development (see Meyer 1999: Figure 2-6). These studies recognize that the amount of soil development is dependent on time, weathering, parent materials, and the geomorphic position of the deposit. Thus, differences in the development of the two soil types can be used to indicate temporal differences that result from differential floodplain stability.

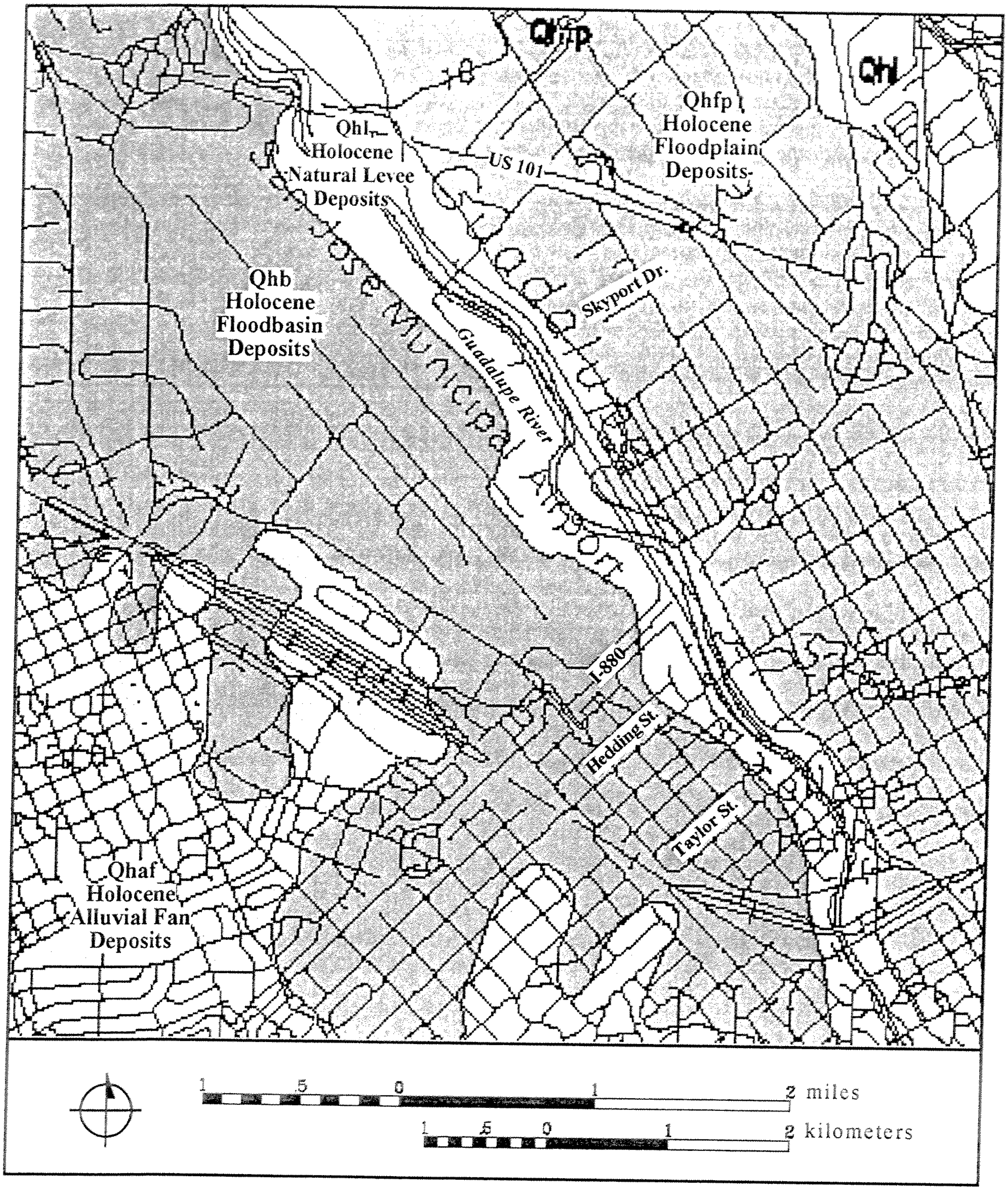


FIGURE 2. Distribution of Surface Landform-Deposits in the Project Area (adapted from Helley et al. 1994)

Basin soils are characterized by thick, very dark-colored A horizons; light-colored, highly calcareous B horizons; and oxidized C horizons, indicative of moderate to strong soil development. These soils correspond with the area mapped as "Holocene Floodbasin Deposits" in Figure 2, and were formed by slow but steady deposition in large alluvial basins. In contrast, the alluvial soils are characterized by thinner A horizons, absent to moderately developed B horizons of accumulated clay and/or carbonates, and unweathered C horizon, indicative of weak to moderate soil development. The older alluvial soils correspond with the area mapped as "Holocene Floodplain Deposits," while the younger alluvial soils correspond with the area mapped as "Holocene Natural Levee Deposits" in Figure 2. Unlike the basin soils, the alluvial soils were formed by relatively rapid deposition in or near active channels.

Using these distinctions, the basin soils are considered to be older than the alluvial soils. Based on this and available radiocarbon evidence, the basin soils are estimated to be Early to Middle Holocene in age, while the alluvial soils are estimated to be Late Holocene to Historic in age at the surface (see Meyer 1999: Figure 2-6). However, it is noted that the variable development of the alluvial soils indicates that they were formed by separate episodes of deposition that occurred at substantially different times. Further details regarding the apparent age, nature, and extent of the soil and sediment types are provided in Chapter 2 of the HPTP (Meyer 1999:20-25).

River History

The historical evidence indicates that flooding, ground subsidence, and the construction of dams and levees over the last 230 years have dramatically altered the channel and banks of the Guadalupe River. Early accounts describe the Guadalupe River as having high (incised) banks and a watercourse that was deep, swift, and full-flowing. The bed and banks of the river were lined with many trees (including ash, laurel, cottonwood, sycamore, and willow), while the surrounding floodplain was very large, level, and generally without trees or stones (Bolton 1927, 1933). The Guadalupe often overflowed it banks, particularly in the northern part of the project area, where flood waters destroyed the first Santa Clara Mission site in 1779 (Spearman 1963). This portion of the river continued to flood until the channel was realigned and artificial levees constructed by the Corps of Engineers in 1960-61 (Spearman 1963:90). A comparison of modern and historic maps (Thompson and West 1876; USGS 1899) indicates that the present river course lies hundreds of feet from its historic course in some portions of the project corridor (Figure 3).

During the 20th century, the rapid groundwater withdraw caused the land along the Guadalupe River to subside some 1.8 m to 2.4 m (6 to 8 ft.) below its former elevation within the APE (Poland and Ireland 1988). As a result, the course of the river was lowered with respect to its outlet near Alviso, as the river must now cross a basin created in the area of maximum subsidence between San Jose and Agnew. The differential subsidence of the valley floor has probably resulted in the relatively rapid deposition of recent alluvial sediments along that portion of the river channel (Fentress 1979:56). The nature, completeness, and visibility of the prehistoric and historical archaeological record in the project area have almost certainly been affected by these historic changes in the river course. Additional information about the river and its history are provided in the HPTP (Meyer 1999:27-28, 167, 183).

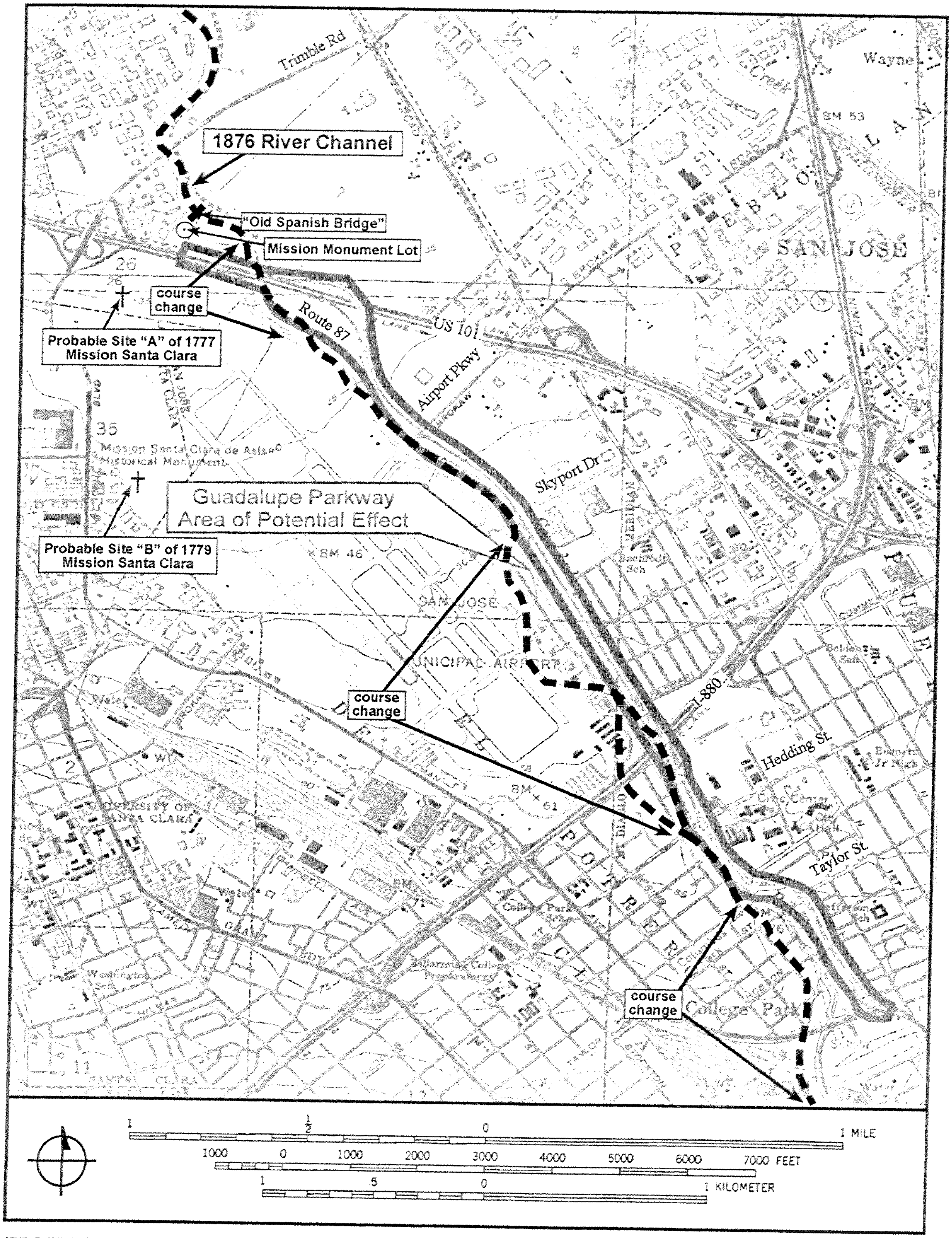


FIGURE 3. Modern River Course Compared to 1876 River Course (after Thompson and West 1876). Arrows mark changes in river course -- note bifurcated channel. Probable bridge and mission locations after Spearman (1963).

ARCHAEOLOGICAL VISIBILITY AND SENSITIVITY

Introduction

One of the most difficult issues faced by archaeological investigations in the valleys of central California is the need to locate and analyze previously unknown prehistoric sites. At the most basic level, archaeological resources cannot be conserved, mitigated or otherwise managed unless they are first identified. Given that archaeological inquiry depends largely on the analysis and cumulative integration of various datasets, it is particularly important that a reasoned attempt is made to locate undiscovered archaeological resources. Without new or comparative data, many of the most basic questions regarding chronology, settlement, and subsistence cannot be properly addressed or answered, and current research questions cannot be confirmed, denied, or refined. Thus, the need to discover and identify the location of additional prehistoric sites is one of the most critical, if not fundamental, research issues to be addressed by archaeological investigations in the project APE.

Researchers have often interpreted the frequency and distribution of Late-Holocene archaeological deposits in central California as prima facie evidence of settlement and population changes during the upper Archaic and Emergent periods (e.g., Bouey 1987:66; Broughton 1994; Schulz 1981:184). At first glance, the predominance of Upper Archaic and Emergent-period sites in central California seems to support the notion of population increase. Current models view these demographic changes as attendant with more intensive subsistence strategies, which eventually lead to increased organizational complexity (Basgall 1987; Beaton 1991; Bouey 1987; Broughton 1988, 1994; Jones 1992). These models suggest that imbalances between population and resources during the middle Archaic were sufficient to have initiated the intensified economy's characteristic of later adaptations (Basgall 1987; Beaton 1991; Bouey 1987; Broughton 1994; Jones 1992).

While it is reasonable to assume that Upper Archaic and Emergent period populations were greater than those of preceding periods, the mechanism and overall trajectory of prehistoric population growth is poorly understood in central California (Beaton 1991:950-951). This situation is largely a product of the apparent absence of Lower- to Middle-Archaic archaeological deposits that can provide direct evidence of human settlement and population. Researchers have acknowledged that large-scale landscape changes have likely buried these older sites in central California (Banks, Orlins, and McCarthy 1984; Bickel 1978a, 1978b; Beaton 1991:948; Fredrickson 1980; Jones 1992:8; Schulz 1981:184), however, only a few deeply buried archaeological sites dating to more than 5,000 years ago have been discovered (Gerow 1974; Henn, Jackson, and Schlocker 1972; Meyer and Rosenthal 1997). As such, relatively few studies have systematically examined the potential influence of large-scale geological processes on regional site-distribution patterns.

History of Problem in Project Area

Over the past 20 years, nearly every archaeological investigation conducted in the Guadalupe River floodplain has noted: (1) that many prehistoric (especially Middle period) sites are buried; and/or (2) that the area has considerable potential for containing additional buried sites (Ambro 1996; Anastasio 1984; 1988; Bard et al. 1986; Cartier 1980; 1988; Fentress 1979; Findlay and Garaventa 1983; Hylkema 1998). Although the problem of locating buried sites in the area has been acknowledged my most investigators (Ambro 1996:14; Anastasio 1984:7; Cartier 1988:277), "(a) reliable model for predicting prehistoric cultural resource locations based on current site data, types and topographic and environmental variables has not yet been developed for the Santa Clara Valley" (Hylkema 1998:25).

Previous archaeological studies have suggested that there is a connection between geological processes and the distribution of prehistoric sites in the Guadalupe River floodplain. Bergthold determined that most prehistoric sites in the northern Santa Clara Valley are located along or near

streams and rivers (1982:218). Despite Bergthold's assumption that site distributions reflect a cultural preference to avoid frequently flooded areas, most residential sites on the Guadalupe River floodplain are located in areas that are known to have flooded frequently in historic times (see Meyer 1999:174). Given this circumstance, Bergthold also acknowledged that site distributions might reflect geological processes that buried or destroyed some prehistoric sites in the area (1982:220-222). An apparent relationship between sites and soil types was noted by Anastasio (1988) who observed that Upper Archaic period sites in the Guadalupe River floodplain tend to be associated with basin soils, while Emergent period sites tend to associated with alluvial soils.

Thus, while the original distribution of archaeological sites is a product of cultural factors, the current distribution of sites reflects the influence of natural factors that determined the preservation and visibility of site distribution patterns. Thus, present environmental conditions (e.g., present location of water) cannot necessarily be interpreted as being representative of the conditions that may have influenced, or been encountered by, people in the past. In recognizing this problem, Caltrans archaeologist, Mark Hylkema, requested that a geoarchaeological sensitivity assessment be developed in an effort to estimate the potential for buried archaeological resources in the project corridor.

Sensitivity Assessment

The preliminary assessment of geoarchaeological sensitivity in the project APE is found in Chapter 7 of the HPTP (Meyer 1999:159-181) The assessment describes the theoretical perspective, applied concepts, predictive modeling, survey methods and sampling bias, and the findings of previous studies that have used a geoarchaeological landscape approach for identifying potentially buried archaeological resources. The study examines (1) the nature and extent of artificial cut and fill; (2) the age, type, and extent of landform-deposits; (3) the age, depth, and distribution of archaeological sites in the project area in an effort to estimate the potential for buried archaeological resources within the APE.

The assessment recommended the use of a geoarchaeological approach for identifying potentially buried archaeological resources in the project APE. The approach attempts to locate buried archaeological resources by targeting segments of the landscape (landform-deposits) that were most stable and available for prehistoric human use and occupation, while ruling out those that were unstable and/or unavailable. The primary goal of this approach is to reduce the area and/or volume of deposits that need to be searched or monitored, thereby increasing the likelihood that potentially buried archaeological resources will be identified. The primary factors governing the use of this approach in the project area are summarized below.

Artificial Cut and Fill

Given the apparent extent of human settlement, agriculture, river channeling, and urban development in and along the project corridor, it is reasonable to assume that every natural surface has undergone some degree of artificial cutting or filling. Artificial deposits may include asphalt or concrete pavement, modern cultural debris, and reworked natural deposits. Although the extent of these deposits is not fully known, artificial fill is expected to occur at numerous locations within the APE. One such location is the area between Hedding Street and Ferrari Street, where it appears that the project corridor is situated over the former river channel (Figure 3). Given the potential extent and idiosyncratic nature of these deposits, conventional surface survey methods will not be adequate for identifying potential archaeological sites that may be located beneath these deposits.

Landform-Deposits

Two major landform-deposits were identified in the project APE, consisting of a large area of alluvial soils located east of the river, and smaller, isolated areas of basin soils located west of the

river (see Meyer 1999: Figure 2-6). Preliminary evidence indicated that the basin soils were at least middle Holocene in age (~5,000 years old), while the alluvial soils, which were generally less than 1,500 years old (see *Soil and Sediment* above). It appears that portions of both landform-deposits have been buried by Historic-age alluvium on either side of the river from about Hedding Street north to US 101, corresponding with an area of natural levee deposits (Figure 2).

Archaeological Sites

The age, depth, and distribution of prehistoric archaeological sites were compared at a general level for the entire South Bay area, and in greater detail for the area within 2.5 miles of the project APE (Figure 4). A comparison of radiocarbon dates from 57 contexts in the South Bay (including those within 2.5 miles of the APE) shows that there is a strong, but clearly non-linear, relationship between the age and depth of the deposits (Figure 5). Radiocarbon dates from archaeological sites on the Guadalupe floodplain are dominated by contexts that are Late Holocene in age, with only one Middle Holocene-age site (SCL-484) so far identified within 2.5 miles of the project APE (Figure 5). The figure illustrates that Middle Holocene deposits are about 2 times as deep as late Holocene deposits, while Late Pleistocene to Early Holocene deposits are nearly 3.5 times as deep as Late Holocene-age deposits. While the depth of late Holocene contexts ranges from more than 5 m (16.4 ft.) to near surface, these contexts occur at an average depth of about 1 m (3 ft.) below surface.

An analysis of the relationship between site age and landform-deposits revealed that sites associated with basin landforms range in age from 5630 to 760 cal B.P., while sites associated with alluvial landforms range in age from 1580 to 295 cal B.P.; sites dating between 1580 and 760 cal B.P. are associated with both landform-deposits (Figure 5). Thus, it appears that the basin soils formed on landforms that were relatively stable and generally available for human occupation throughout the middle Holocene and most of the late Holocene, while the alluvial soils were deposited between 3,000 and 1,500 years ago. The widespread occupation of the alluvial soil landforms after 1,500 years ago indicates that they have remained relatively stable since that time. These findings suggest that: (1) Middle and Upper Archaic period archaeological sites are almost exclusively associated with the basin landforms; (2) sites that date from 1,300 to 700 years ago (Late Middle period Transition to Middle Phase 1 of the Emergent period) are associated with both landform-deposits; and (3) sites that date to less than 700 years (Late Phase 1 and Phase 2 of the Emergent period) are associated exclusively with alluvial landforms.

Of the 45 sites identified within 2.5 miles of the project APE (Figure 4), approximately 40% occur at or near the surface, while the remaining 60% occur in buried contexts. A schematic cross section was developed to evaluate the relationship between the major landform-deposits and site locations within 2.5 miles of the project area (Figure 6). The figure shows that sites associated with alluvial soils outnumber those associated with basin soils by at least two-to-one, with the majority (60%) of the buried sites occurring where alluvial soils are mapped at the surface. Figure 6 also illustrates that buried sites outnumber surface sites in each of the major landform-deposits. The percentage of buried sites associated with each major landform-deposit are summarized in Table 1, while the difference between the number of surface and buried sites associated with the landform-deposits is shown in Table 2.

TABLE 1. PERCENTAGE OF BURIED SITES BY MAJOR LANDFORM-DEPOSITS

Landform-Deposit	Percentage of Buried Sites
Alluvial soils	40%
Basin soil	26%
Alluvial-over-Basin soil	23%
Alluvial-over-Alluvial soil	11%

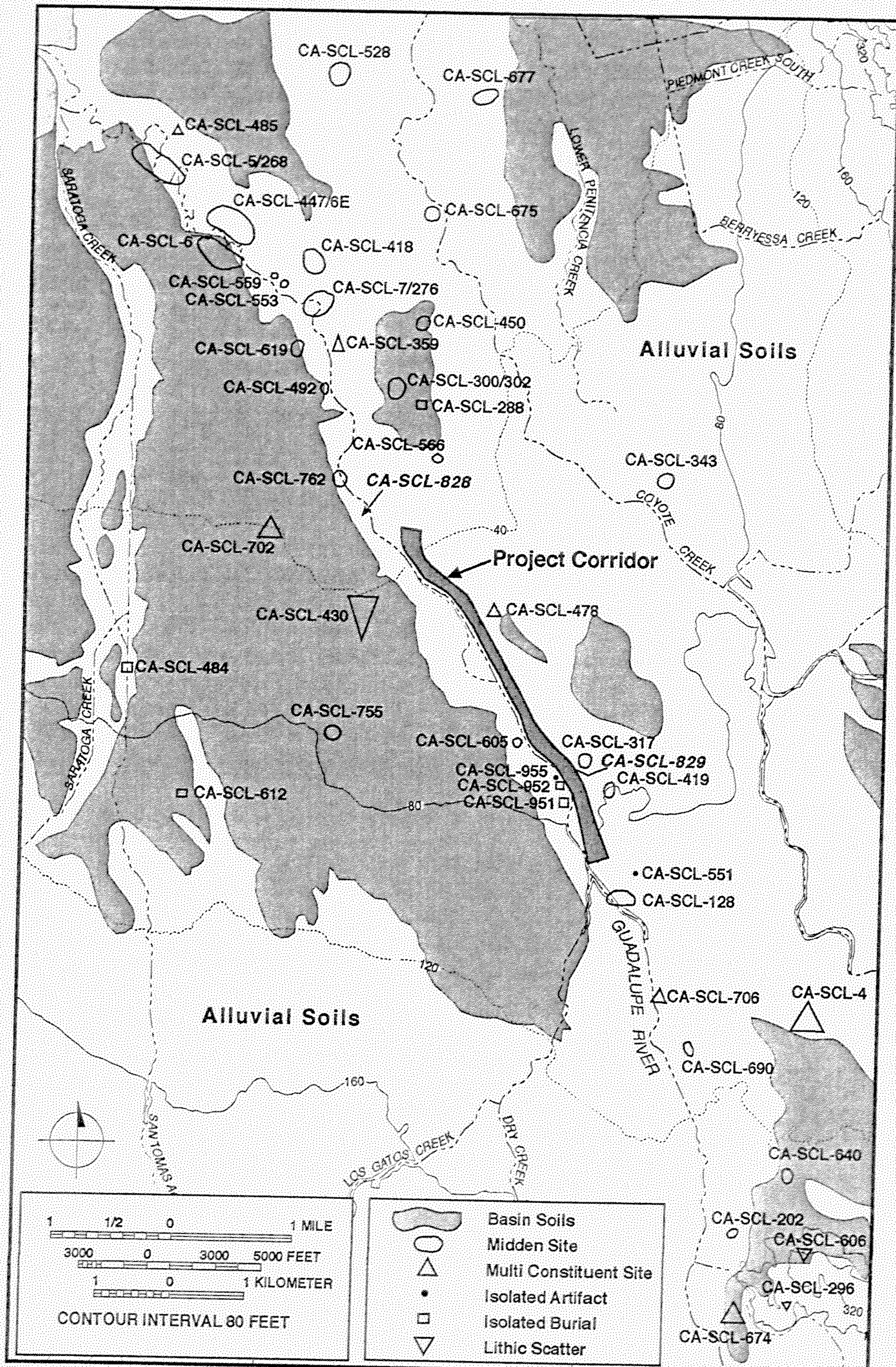


Figure 4. Distribution of Prehistoric Sites and Major Landform-Deposits

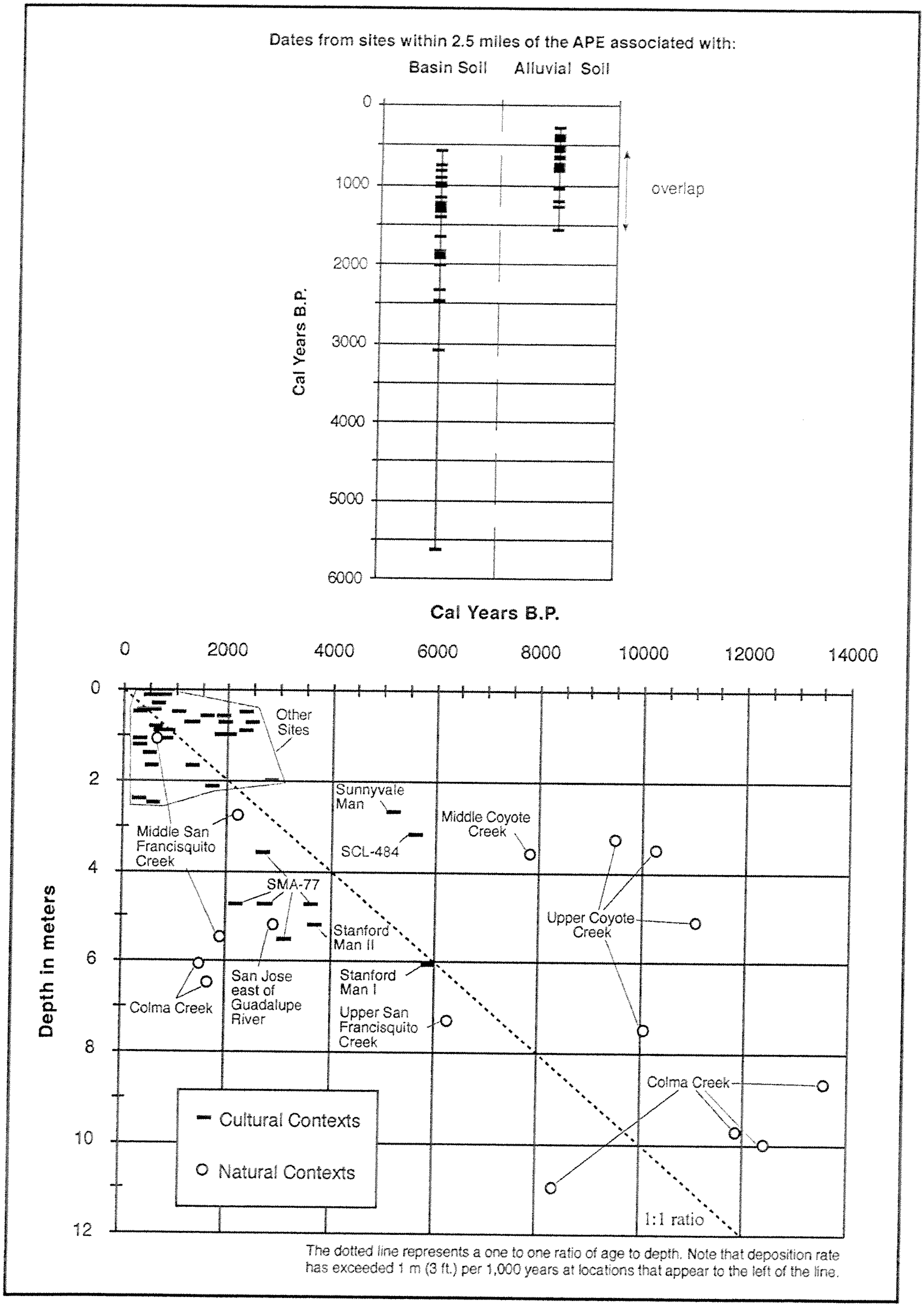
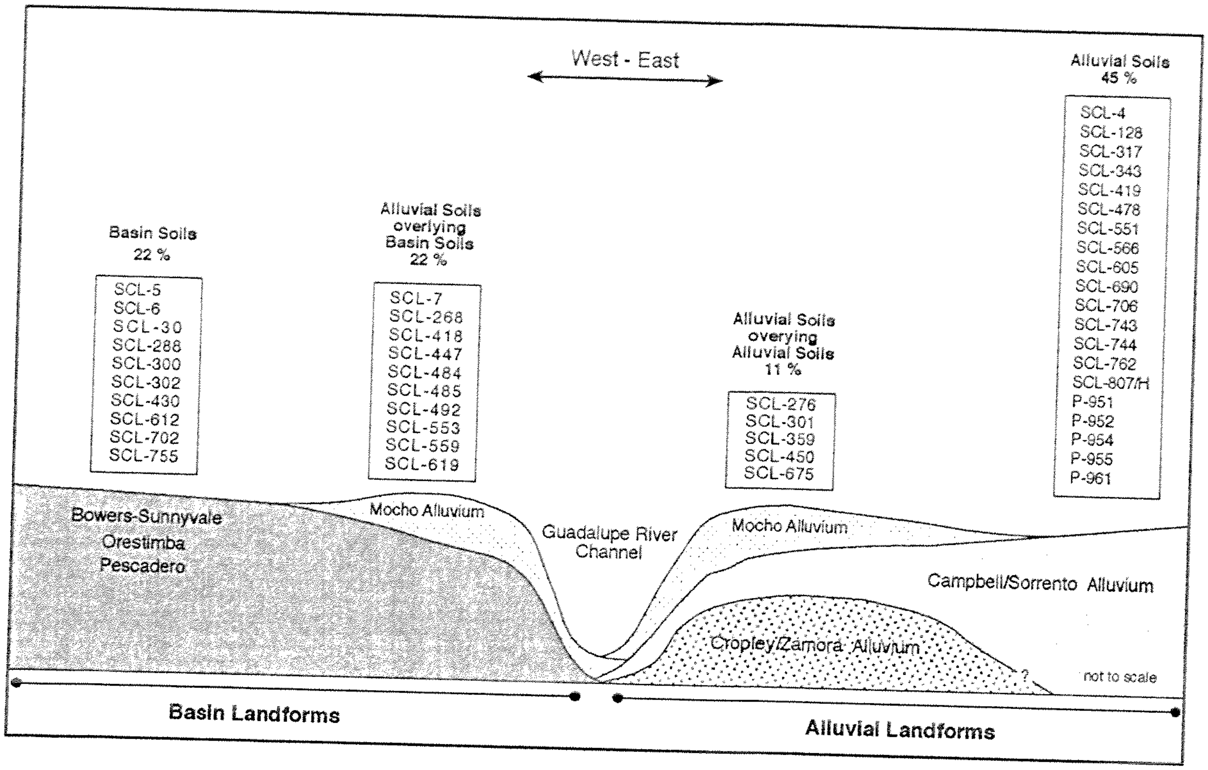
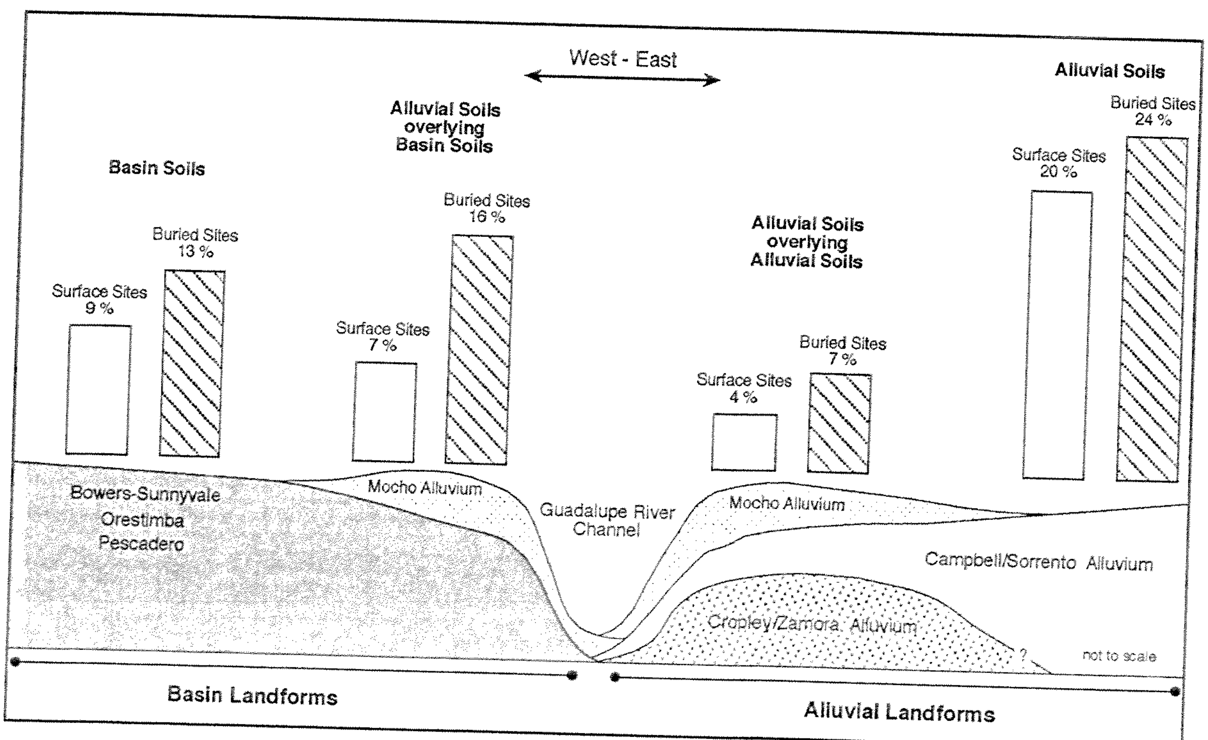


FIGURE 5. Comparisons of Radiocarbon Dates from South Bay Contexts





Note: percentages based on the total number of all sites as compared to soil types.

FIGURE 6. Distribution and Percentage of Archaeological Sites within 2.5 Miles of the Project APE According to Major Soil Types and Landform-Deposits

TABLE 2. COMPARISON OF BURIED AND SURFACE SITES BY LANDFORM-DEPOSITS

Description	Alluvial Soils	Alluvial-over-Alluvial Soils	Basin Soils	Alluvial-over-Basin Soils
Number Surface Sites	9	2	4	3
Number of Buried Sites	11	3	6	7
Ratio of Buried to Surface Sites	1.2 to 1	1.5 to 1	1.5 to 1	2.3 to 1

Although most buried sites are associated with the alluvial landforms, the chance of encountering buried sites is greatest in areas where basin landforms that are overlain by alluvial landforms. This difference is probably related to the relative stability of the basin landforms as compared to the alluvial landforms, cultural preferences notwithstanding. These relationships suggest that the age and distribution of known prehistoric sites along the Guadalupe River incompletely reflects human demography and settlement patterns. Instead, the natural processes associated with landscape evolution have buried much of the evidence of human use and occupation in the area.

The result of the sensitivity assessment can be summarized as follows:

1. Most of the sites within 2.5 miles of the APE are late Holocene in age
2. Most of the sites are buried at an average depth of 1 m (3 ft.)
3. Most of the sites are associated alluvial soil types
4. All of the sites greater than 1,600 years old are associated with basin soils
5. Most of the buried sites are located in areas with alluvial soils at the surface; and
6. The alluvial-over-basin landforms have the greatest potential for buried sites.

Buried Archaeological Potential

Based on the findings of the sensitivity assessment, the potential for buried archaeological resources in the project APE were estimated using the following criteria:

1. The presence or absence of a paleosol buried during the Holocene
2. The apparent preservation or erosion of a buried paleosol surface
3. The relative or absolute duration of landform stability represented by a paleosol
4. The presence or absence of a present or former watercourse within 1/2-mile; and
5. The relative proximity of a buried paleosol to a present or former watercourse.

The relationship between these criteria and the potential for buried archaeological resources are summarized in Table 3.

TABLE 3. CRITERIA USED TO ESTIMATE ARCHAEOLOGICAL POTENTIAL

Criteria (expected conditions)	Buried Archaeological Potential*			
	None (lacking)	Low	Moderate	High
Artificial or channel fill	+	-	-	-
Eroded, Holocene-age paleosol	-	+	-	-
Holocene-age paleosol	-	+	+	+
Less than 1/2 mile from watercourse	-	-	+	+
Buried archaeological remains in same landform-deposit	-	-	-	+

*Note: 1 criteria required for none and low, 2 criteria for moderate, and 3 criteria for high potential.

By applying these criteria to the expected conditions in the project APE, the estimated potential for buried archaeological resources was found to vary according to the apparent age, type, and extent of the landform-deposits present in different segments of the APE (Table 4), Based on this assessment, most of the project APE has a moderate to high potential for containing buried archaeological resources. However, the assessment represents a preliminary framework for future archaeological investigations that can, and should, be revised and/or refined, as additional data becomes available and new discoveries are made (Meyer 1999:164). As Table 4 indicates, much of the APE's archaeological potential derives from its proximity to the present and/or former course of the Guadalupe River, which is assumed to have served as a focal point for prehistoric human use and settlement, and as a source of alluvial sedimentation during the Holocene.

TABLE 4. ESTIMATED ARCHAEOLOGICAL POTENTIAL OF APE SEGMENTS

APE Segments (from north to south)*	Buried Archaeological Potential**			
	None (lacking)	Low	Moderate	High
Northwest: (Guadalupe River west to Trimble Road along US 101)	-	-	+	+
Northeast: (Guadalupe River east to Route 87 along US 101)	-	-	+	+
East-Central: (Hedding St. north to Ferrari St. east of river)	+	+	-	-
(Ferrari St. north to I-101 east of river)	-	-	+	+
Southwest: (Talyor St. west of Guadalupe River)	-	-	+	+
Southeast: (East St. James St. north to Hedding St. east of river)	-	-	+	+

* Skyport Drive (west of river), and Highway 101 (west of Trimble Road) were not included in this study.
** Estimated using the qualitative application of criteria in Table 3 to expected conditions in the APE.

Based on the sensitivity assessment, geoarchaeological exploration was recommended for the segments that were estimated to have a moderate to high potential for buried archaeological resources (Table 4). However, no exploration was recommended between Hedding and Ferrari Street because the potential for buried archaeological resources in this segment was estimated as being none to low.

FIELD AND LABORATORY METHODS

Introduction

Field and laboratory investigations were conducted to identify, document, and evaluate the nature and general extent of the landform-deposits in the project area. The field and laboratory methods used for this investigation are described below.

Field Visit

A preliminary field visit was conducted to examine natural cutbanks and excavated exposures in and near the project APE, and to assess the accuracy of various published maps and information sources. The banks of the river near Skyport Drive were also examined to determine if the buried paleosols that appear in Figure 5 of Busby (1997) were still exposed; however, no sections were found, apparently due to landscaping and vegetation cover. Exposures recently excavated by the Army Corps of Engineers in the southwest segment (west of the Guadalupe River at proposed Taylor Street bridge) were examined and radiocarbon samples collected from two buried paleosols. Given the APE is covered by extensive pavement and/or dense vegetation, no other useful exposures were found within the project corridor.

Backhoe-Trenching

Subsurface exploration trenches were excavated in the project area using a tractor-mounted backhoe to: (1) identify and document the stratigraphy of natural land-form deposits; (2) search for potentially buried archaeological materials; and (3) obtain appropriate samples for radiocarbon dating analysis. Trenches were excavated within those segments estimated to have a moderate to high potential for buried archaeological (Table 4). The exact location and size of the trenches was determined in the field, depending on the existing conditions and the results of previous trenching. Each trench was designated according to the month, day, and the number of trenches excavated that day (e.g., 10-4-1 is the first trench excavated on 4 October). The majority of these trenches were about 1 m (3 ft.) in width, 3 m (9.8 ft.) in depth, and 4 m (13.1 ft.) in length, however, trench length and depth varied from one location to the next. Project personnel were not be allowed to enter a trench more than 1.5 m (5 ft.) in depth until the trench was secured with hydraulic-shoring devices in accordance with OSHA standards.

The presence or absence of archaeological materials was determined by checking the deposits as they were removed from the trenches, and by examining the trench walls. At least 720 m3 of deposits were excavated from the trenches and checked for the occurrence of archaeological materials. The depth and general nature of the deposits were recorded in the field, with additional attention given to those trenches that contained buried archaeological remains; selected trenches were drawn and described in greater detail. The trench locations were mapped or plotted on existing maps with the assistance of Greg White and Denise Thomas of the Chico State University Archaeological Research Program. Samples of soil, sediment, and charcoal were collected from appropriate contexts for flotation and/or radiocarbon dating analysis. All of the trenching and shoring was supervised by the project geoarchaeologist. The findings made while backhoe-trenching were used to refine the exploration strategy while still in the field.

Stratigraphic Identification and Description

Natural and cultural stratigraphy was identified by carefully examining the deposits exposed in the sidewalls of the exploration trenches in the project area. Stratigraphic units were identified on the basis of parent materials, superposition, and relative soil development. The stratigraphic units were assigned roman numerals (I, II, III, etc.) from the oldest to the youngest unit as they appeared in each exposure. Master soil horizons are designated by upper case letters (A, B, or C) that are proceeded by arabic numerals (2, 3, etc.), which indicate that the horizon is associated with a different

parent material (1 is understood but not shown). Subordinate soil horizons are designated by lower case letters as follows: (1) "p" is a zone of fill or artificial disturbance; (2) "b" is a buried genetic horizon at the location where it was described (not used with C horizons) (3) "t" is a subsurface (illuvial) accumulation of silicate clay; (4) "k" is a subsurface accumulation of pedogenic carbonate; (5) "w" is a weak subsurface change in color or structure (used only in B horizons); (6) "u" is relatively unweathered parent material; and (7) "ox" is the presence of oxidized minerals (mottles). A combination of these numbers and letters are used to indicate the important characteristics of a particular soil horizon. These designations are consistent with those outlined by Birkeland, Machette, and Haller (1991), Schoeneberger et al. (1998), and the Soil Survey Staff (1998).

Buried paleosols were identified in the field on the basis of color, structure, horizon development, bioturbation, lateral continuity, and the nature of the upper boundary with the overlying deposit (Birkeland, Machette, and Haller 1991; Retallack 1988). The paleosols often exhibited abandoned root and insect holes, or other indications of bioturbation. Subsurface accumulations of clay or carbonates and/or distinct angular blocky structures were identified as B horizons. Sediments with relatively little evidence of near-surface weathering were identified as C horizons.

Flotation Samples

Two flotation samples were processed by Brian Gassner of the Anthropological Studies Center at Sonoma State University, using a manual flotation system that consists of a wooden box with 0.5mm screen and a hand screen with 0.25-mm mesh (Hunter 1998). The sample was placed in the box and the box was placed in a water-filled container. The sample was then hand-agitated, allowing any charred remains (light fraction) to float and be skimmed from the water's surface using the hand screen.

The recovered light fraction was dried and sorted through nested geologic sieves to create fractions that are >2.0 mm, >1 mm, >0. 5, and <0.3 mm in size. Each of these fractions was then examined under a binocular microscope at 8x to 50x magnification. All the charred remains from the >2.0 mm and >1.0-mm fractions were separated by material type, then counted and weighed accordingly. Charred materials recovered in the >0.5 mm fraction was not separated, counted, or weighed. Due to the fragmentary nature of the materials, no attempt was made to identify the charcoal/wood types. Additional information regarding the analysis of the flotation samples is provided in Appendix B.

Pollen Samples

G. James West, Ph.D., of Brienes, West & Shulz in Davis, California, processed three pollen samples, using standard chemically based palynological extraction procedures. In order to determine the pollen count, each sample was swirled and screened to minimize the larger inorganic fraction. Tablets with exotic *Lycopodium* spores were added to each sample as a check on the processing methods, and to determine pollen concentration values. A fraction of each processed sample was mounted on a glass slide and examined through a Nikon microscope using Kohler and phase contract illumination. Additional information regarding the analysis of the pollen samples is provided in Appendix C.

Radiocarbon Samples and Dating

Radiometric analysis was conducted to establish and refine the chronology of natural and cultural contexts in the project area. Radiocarbon (14C) is produced primarily by the interaction of cosmic radiation with nitrogen in the earth's atmosphere. After mixing with carbon dioxide (CO2), 14C is readily assimilated by plants and other living organisms. When plants and animals die, however, 14C levels start to decrease because they no longer absorb new carbon. Since 14C is known to decay at a rate that approaches a half-life of 5,730 years, the amount of decay reflects the

age of biogenic carbon as compared to modern levels of 14C activity (Geyh and Schleicher 1990). For consistency, the half-life of 14C is set at 5,568 years by international convention.

A total of 12 samples were submitted to Beta Analytic, Inc. in Coral Gables, Florida for radiocarbon dating analysis; these samples consisted of shell, charcoal, soil, and organic sediment. Soils and sediments can be dated if they contain certain amounts of biogenic carbon in the form of organic matter or secondary carbonates (i.e., soil organic matter or SOM). The differential decomposition, humification, and translocation of biogenic carbon in a given deposit determine the type and amount of SOM available for dating. The accuracy of soil dates depends on the researcher's ability to select samples that will minimize potential contaminants (Scharpenseel 1979) and to properly interpret the context of the sample (Matthews 1985). The 14C age of a soil or sediment reflects the apparent mean residence time (AMRT) of the total organic content of the analyzed material. Since soil formation is time-transgressive, AMRT dates are usually younger than the true age of the soil. Understood in this way, the 14C age of a soil does not mark a single time or event, but reflects the influence of multiple processes that affect the soil carbon system over time.

Measured 14C ages also reflect the enrichment or depletion (fractionation) of stable carbon isotopes 12C and 13C as determined by the metabolic and environmental history of a sample (Geyh and Schleicher 1990). For this reason, 13C/12C ratios are often used to correct measured 14C ages to conventional 14C ages, which are expressed in years before present (B.P.), with present equaling A.D. 1950. Due to fluctuations in the concentration of atmospheric 14C over time (the de Vries effect), conventional 14C ages can differ from the actual ages in solar years. This difference amounts to only $\pm$ 200 years over the past 2,000 years, but increases to -800 years between 2,000 and 7,300 years ago, and to -1,100 years between 8,000 and 11,000 years ago (Geyh and Schleicher 1990:168). To compensate for these differences, high-precision calibration programs were developed that convert conventional 14C ages into calibrated years (cal B.P.) (Stuiver and Reimer 1993). The application of calibrated ages is especially important when attempting to order and compare groups of related samples (Buck, Litton, and Scott 1994). In this report, conventional radiocarbon dates are followed by the designation "B.P.", while calibrated dates are followed by the designation "cal B.P." The specific laboratory calibration methods used for the radiocarbon analysis of samples from the project area are provided in Appendix A.

Carbon Isotope Analysis

Carbon isotope (13C/12C) ratios were obtained from samples collected in the project area as part of the radiocarbon analysis. These ratios have been used by some archaeological studies as a method for reconstructing past environments (DeNiro 1987; Tieszen 1991; van der Merwe 1982). This approach is based on the recognition that most plants either metabolize carbon dioxide along Calvin pathways (3C), or along Hatch-Slack (4C) pathways during photosynthesis (Stout, Rafter, and Troughton 1975). Studies have determined that both plant types have distinctive 13C/12C ratios, with C3 type plants ranging between -33 to -22‰, and 4C type plants ranging between -16 to -9‰ (DeNiro 1987). It has also been shown that lower temperatures and regular amounts of moisture favor the growth of 3C plants, whereas higher temperatures and restricted amounts of moisture favor the growth of 4C plants (Krishnamurthy and Bhattacharya 1989). By monitoring variations in the proportion of 3C and 4C plants over time, 13C/12C ratios have been used to indicate warmer/drier versus cooler/moister paleoecological conditions (Balesdent, Girardin, and Mariotti 1993; Cerling, Quade, and Bowman 1989; Dorn and DeNiro 1987; Stuiver and Braziunas 1987). An analysis of the carbon isotope ratios obtained from the project area is provided in the *Analysis and Discussion* section below.

SUBSURFACE EXPLORATION RESULTS

Introduction

Field investigations were performed in the project APE between 4 and 8 October 1999. Subsurface exploration trenches were excavated at 60 locations in the northwest, east central, and southeast segments of the project area using a tractor-mounted backhoe. Subsurface explorations were not conducted in the northeast and west-central segments due to limited access, and the availability of similar deposits elsewhere in the APE. No exploration was conducted in the southwest segment due to recent excavations and the availability of exposed subsurface deposits. As a result, two previously unidentified prehistoric archaeological deposits (CA-SCL-828, "Fuel Farm" and CA-SCL-829, "Taylor Street") were discovered within the project APE. The preliminary results of this work was presented in *Phase 1.5 Prehistoric Archaeology Results, Route 87 Guadalupe Corridor Freeway Project, San Jose, Santa Clara County, California*, by White and Thomas (1999). This report provides additional technical information about the location of the trenches and the nature and extent of the deposits identified within the trenches that were not included in the Phase 1.5 report. It also presents the results of flotation, pollen, and radiocarbon analyses conducted for this study.

Northwest Section (Fuel Farm)

Exploration of the northwest section was conducted in an open field located just north of US 101, east Trimble Road and west of the Guadalupe River (Figure 1). In addition to the proposed project impacts for this area, the property is being considered as the future location of a fuel storage facility for the San Jose Airport. It appeared that the field had been filled with artificial deposits to elevate the ground surface. A historical monument commemorating the probable location of the first Santa Clara Mission site and the "Old Spanish Bridge", was found along the field's western boundary (Figure 7). According to Spearman (1963), the monument was originally situated in a 12 by 12-foot lot located east of its present location. Based on information that appears on the monument, the Old Spanish Bridge was located in the northwest corner of the field (Figure 7), the probable site "A" of the first mission was located several hundred feet southwest of US 101, and probable site "B" was located just south of the field, within the present right-of-way of US 101 (see Figure 3 and Appendix D).

Approximately 288 m3 of deposits were excavated from 24 trenches located within the segment (Figure 7). As a result, a previously unidentified prehistoric archaeological site (CA-SCL-828, "Fuel Farm") was discovered within the segment. Trench 10-4-3 was selected for detailed description because, (1) it was found to contain a concentration of buried archaeological materials; and (2) it contained deposits that were representative of the deposits exposed in the majority of the other trenches. In addition, two radiocarbon dates were obtained from materials collected obtained within the archaeological site. An examination of the exposed deposits resulted in the identification of five major stratigraphic units, which are described below.

Stratigraphic Units

Unit I consists of black to dark gray clay that exhibits a dark, thick surface horizon (4Ab) and a subsurface horizon of illuvial carbonate (CaCO3) and clay (4Bktb), both indicative of a well-developed soil profile (Figure 8). Slickensides were observed in the lower 40 cm of the A horizon, indicating that the deposit has undergone repeated episodes of shrinking and swelling. The unit's clay-rich texture and the presence of slickensides and CaCO3 nodules indicate that the unit is a basin soil. The upper boundary of the unit occurs at a depth of about 1.5 m in the western part of the segment, and a depth of 2.0 m or more in the eastern part of the segment (Figure 9). The lower boundary of the unit extends to a depth of more than 4.7 m below surface. It appears that a portion of the unit's A horizon was truncated by channel erosion in Trench 10-5-13 (Figure 9).

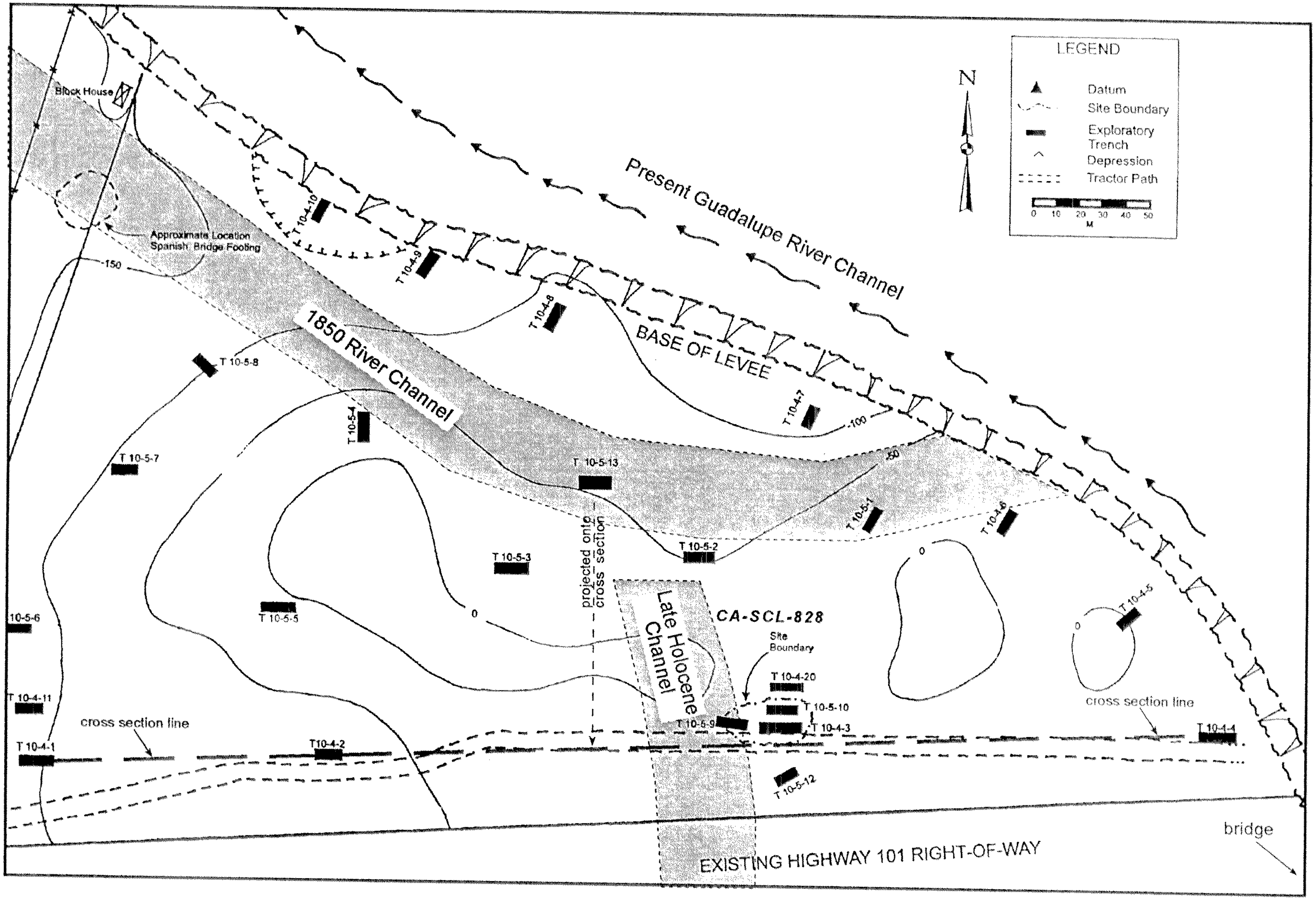


Figure 7. Location of Exploration Trenches in the Northwest Segment. Note: location of 1850 channel based on Spearman (1963:129); location of Late Holocene channel based on test results; "cross section line" shown in Figure 9.

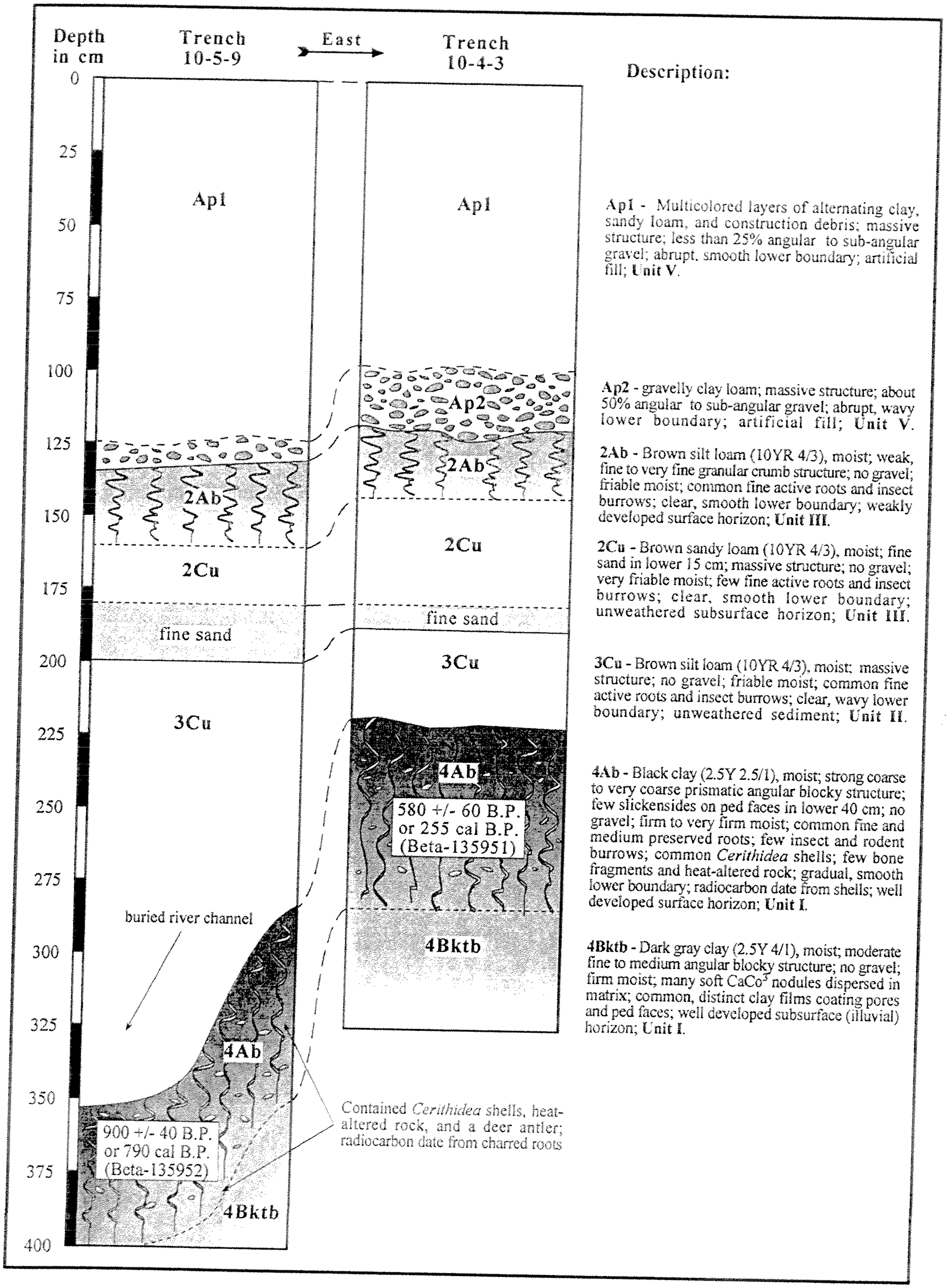


Figure 8. Profiles of Soil Stratigraphy at the Fuel Farm Site (CA-SCL-828)

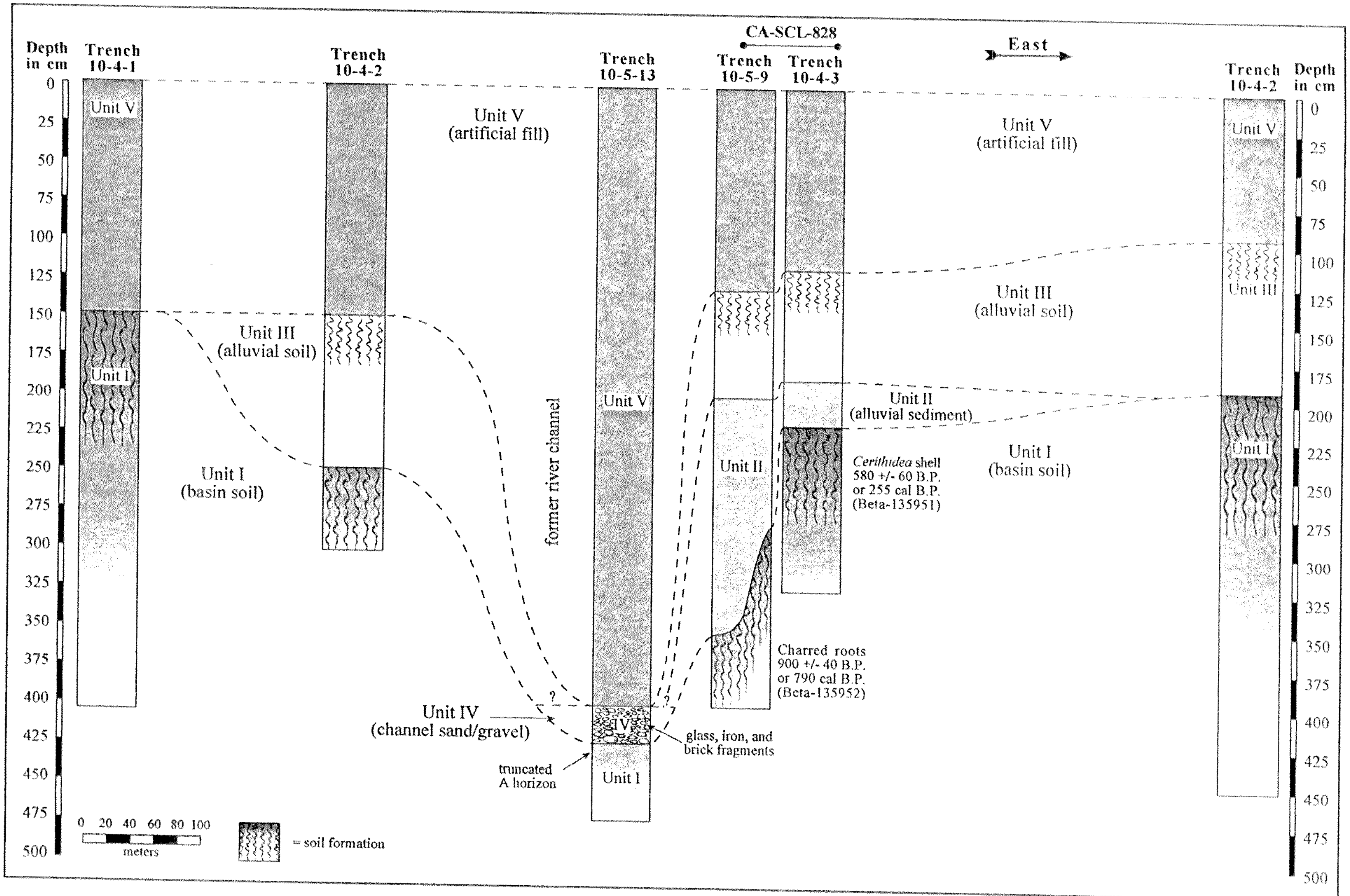


Figure 9. Cross-Section of Stratigraphic Units in the Northwest Segment. Note that trench widths are not to scale.

A concentration of archaeological materials, including *Cerithidea* shells, bone and antler fragments, and heat-altered rock, were recovered from Unit I in Trench 10-4-3 and 10-5-9 (Figure 8). A single square nail was also identified in the upper 10 cm of the unit. Flotation analysis of a soil sample collected at a depth of 240 to 270 cm revealed the presence of some small and fragmentary charred plant remains. These remains include many pieces of wood charcoal, several fragments of California Bay or Laurel nut *(Umbellularia californica)*, and three seeds from the Poaceae family and unidentified seed and/or nut fragments. The archaeological deposit was designated CA-SCL-828 (see White and Thomas 1999 for additional details).

A radiocarbon date of 580 $\pm$ 60 B.P. or 255 cal B.P. (Beta-135952) was obtained from a sample of *Cerithidea* shells collected at a depth of 240 to 270 cm within Unit I (Table 5). A second radiocarbon date of 900 $\pm$ 40 B.P. or 780 cal B.P. (Beta-135952) was obtained from a charcoal sample (charred roots) collected at a depth of 360 to 380 cm in Trench 10-5-9. The Given the stratigraphic and radiocarbon evidence, it appears that Unit I was associated with relatively stable landform that was incised by channel down-cutting during the Late Holocene, and buried by alluvium during the Historic period.

Unit II consists of brown silt loam sediment that has a massive structure, and generally lacks evidence of near surface weathering (3Cu). No archaeological materials were identified in the unit. The nature and stratigraphic position of Unit II indicate that it represents a relatively rapid episode of sediment deposition that occurred during the Historic period. Given this and the unit's restricted horizontal distribution (Figure 9), it appears that the sediments were deposited in and near a formerly active channel of the Guadalupe River. Thus, Unit II represents natural channel fill.

Unit III consists of brown silt loam that grades downward into brown sandy loam, with a layer of fine sand near its base (Figure 8). The unit exhibits a thin surface horizon (2Ab) and an unweathered subsurface horizon (2Cu) that are indicative of a weakly developed soil profile. No archaeological materials were identified in the unit. The nature and stratigraphic position of Unit III indicate that it was formed by a relatively rapid episode of sediment deposition that was followed by a brief period of floodplain stability in the Historic period. The unit was found to be horizontally restricted to the eastern part of the segment, which suggests that the deposit originated from the modern course of the Guadalupe River.

Unit IV consists of channel sand and rounded gravel that lack any evidence of in-place weathering. The unit was found to contain historic archaeological materials such as glass, iron, and brick fragments, which appear to have been rounded due to abrasion within a formerly active channel. This unit was encountered in only one exploration trench (10-5-13)(Figure 9). Based on the nature and apparent age of the historic materials, it appears that this unit represents bedload from the pre-1960 Guadalupe River channel.

Unit V consists of multicolored layers of alternating clay, sandy loam, gravelly clay loam, and modern construction debris. The unit was found to extend to at least 75 cm in depth across the entire the segment, and reached a maximum depth of nearly 4.0 m within the former river channel (Figure 9). The unit represents disturbed and/or artificial materials that have been deposited and/or mechanically distributed across the segment. Based on the historical evidence, it appears that the Unit V probably post-dates 1960.

TABLE 5. RADIOCARBON DATING RESULTS FROM THE GUADALUPE CORRIDOR

Lab No. (Beta-)	Site and/or Segment	Trench or Unit	Material Dated	Min. Depth mbgs	Max. Depth mbgs	C-14 Age	±	C13/C12 Ratio	Max. Cal B.P.	Cal B.P. Inter.	Min. Cal B.P.	AD/BC	Comment
130741	Southwest, Taylor St.	na	Soil	5.27	5.47	6320	70	-25.4‰	7415	7255	7150	BC 5305	2 sigma
130742	Southwest, Taylor St.	na	Charcoal	6.57	6.67	6700	40	-25.7‰	7635	7580	7565	BC 5630	2 sigma, AMS
135951	SCL-828, northwest, "Fuel Farm Site"	10/4/03	Shell (Cerithidea)	2.40	2.70	580	60	-1.6‰	280	255	135	AD 1695	1 sigma with marine correction
135952	SCL-828, northwest, "Fuel Farm Site"	10/5/09	Charcoal (roots)	3.60	3.60	900	40	-26.3‰	910	790	755	AD 1160	1 sigma, AMS
135953	East-central, Airport Parkway	10/6/02	Organic (sediment)	2.90	3.00	12540	110	-22.8‰	15575	14680	14145	BC 12730	2 sigma, middle of multiple intercepts
135954	East-central, Airport Parkway	10/6/02	Soil	2.20	2.40	9150	170	-23.8‰	10715	10250	9890	BC 8300	2 sigma
135955	East-central, Airport Parkway	10/6/02	Soil	1.70	1.90	3130	120	-24.8‰	3620	3360	2990	BC 1410	2 sigma
135956	Southeast, Taylor St.	10/7/01	Soil	2.65	2.85	5100	70	-23.5‰	5985	5895	5660	BC 3945	2 sigma
135957	Southeast, Taylor St.	10/7/01	Soil	4.70	4.80	11620	80	-23.5‰	13855	13735	13320	BC 11785	2 sigma, middle of multiple intercepts
135958	Southeast, Taylor St.	10/7/01	Organic (sediment)	4.40	4.50	9440	90	-24.6‰	11095	10680	10430	BC 8730	2 sigma, middle of multiple intercepts
135959	Southeast, Taylor St.	10/7/01	Soil	3.60	3.80	8840	80	-24.0‰	10190	9910	9580	BC 7960	2 sigma
135960	Southeast, Taylor St.	10/7/01	Organic (sediment)	2.10	2.30	4080	80	-25.7‰	4835	4540	4405	BC 2590	2 sigma
143250	SCL-829, southeast, "Taylor St. Site"	Unit 1	Charcoal (cultural)	1.20	1.30	1420	40	-23.5‰	1335	1310	1295	AD 640	1 sigma

Note: mbgs = meters below ground surface; Cal B.P. Age "Inter" is the date of the single or central intercept.

East-Central Segment (Airport Parkway to Sonora Avenue)

Exploration of the east-central segment was conducted in accessible areas along the east side of the Guadalupe River, within the Route 87 right-of-way between Airport Parkway and Sonora Avenue (Figure 10). Proposed project impacts in this segment include excavating a portion of the eastern Guadalupe River bank for riparian mitigation. At least 132 m3 of deposits were excavated from 11 trenches located in the segment (Figure 10). Trench 10-6-2 was selected for detailed description because it contained deposits that were representative of the deposits exposed in the majority of the other trenches. In addition, three radiocarbon dates were obtained from materials collected from the side-walls of Trench 10-6-2. No archaeological materials were identified within the segment. An examination of the exposed deposits resulted in the identification of seven stratigraphic units, which are described below.

Stratigraphic Units

Unit I consists of very dark gray to dark grayish brown clay loam that exhibits a dark surface horizon (6Ab) and a subsurface horizon of illuvial clay (6Btb), indicative of a well-developed soil profile (Figure 11). The unit contained many abandoned root holes and dispersed charcoal fragments. The upper boundary of the unit was found to occur at a minimum depth of 2.7 m (Trench 10-6-3), and a maximum depth of 3.7 m (10-6-5). The lower boundary of the unit extended to a depth of more than 4.0 m below surface (10-6-5). The unit was not found in Trench 10-6-1 or 10-6-4, which suggests that a portion of the unit's A horizon was truncated by channel erosion (Figure 12). No archaeological materials were identified in the unit. It appears that Unit I is an alluvial soil that represent Late Pleistocene floodplain stability (see below).

Unit II consists of very dark gray clay loam that exhibits an angular blocky structure and abandoned root holes, but otherwise lacks evidence of near surface weathering (5Cu). The unit was found to contain a concentration of charcoal and baked earth fragments; no archaeological materials were identified. It appears that the unit represents a relatively rapid episode of sediment deposition that followed a fire or burn event. Although the unit was identified in only one trench (10-6-2), it is likely that the unit has a greater horizontal extent.

A radiocarbon date of 12540 ± 110 B.P. or 14680 cal B.P. (Beta-135953) was obtained from a sediment sample collected at a depth of 290 to 300 cm within Unit II (Table 5). Flotation analysis of a sample collected from the same depth revealed the presence of numerous pieces of woody charcoal, and a single charred seed that appears to be *Polyganum* (see Appendix B). A sample of the sediment was also submitted for pollen analysis, however, no pollen grains were identified. Given the stratigraphic and radiocarbon evidence, it appears that Unit II is an alluvial sediment that represents an episode of burning and rapid alluvial deposition that occurred during the Late Pleistocene.

Unit III consists of dark grayish brown clay that grades downward into light olive brown silt loam (Figure 11). The unit exhibits a dark surface horizon (4Ab), a weakly structured subsurface horizon (4Bwb), and an unweathered subsurface horizon (4Cu), indicative of a weak to moderately developed soil profile. The upper boundary of the unit was found to occur at a minimum depth of 2.0 m (Trench 10-6-11), and a maximum depth of about 3.0 m (10-6-6). The lower boundary of the unit extended to a maximum depth of 4.1 m below surface (10-6-5). The unit was not found in Trench 10-6-1 or 10-6-4, which suggests the unit was removed by channel erosion at those locations (Figure 12).

A radiocarbon date of 9150 ± 70 B.P. or 10250 cal B.P. (Beta-135954) was obtained from a soil sample collected at a depth of 220 to 240 cm within Unit III (Table 5). No archaeological materials were identified in the unit. Given the stratigraphic and radiocarbon evidence, it appears that Unit III is an alluvial soil that represents an episode of deposition and subsequent floodplain stability that occurred during the Early to Middle Holocene (see Figure 11).

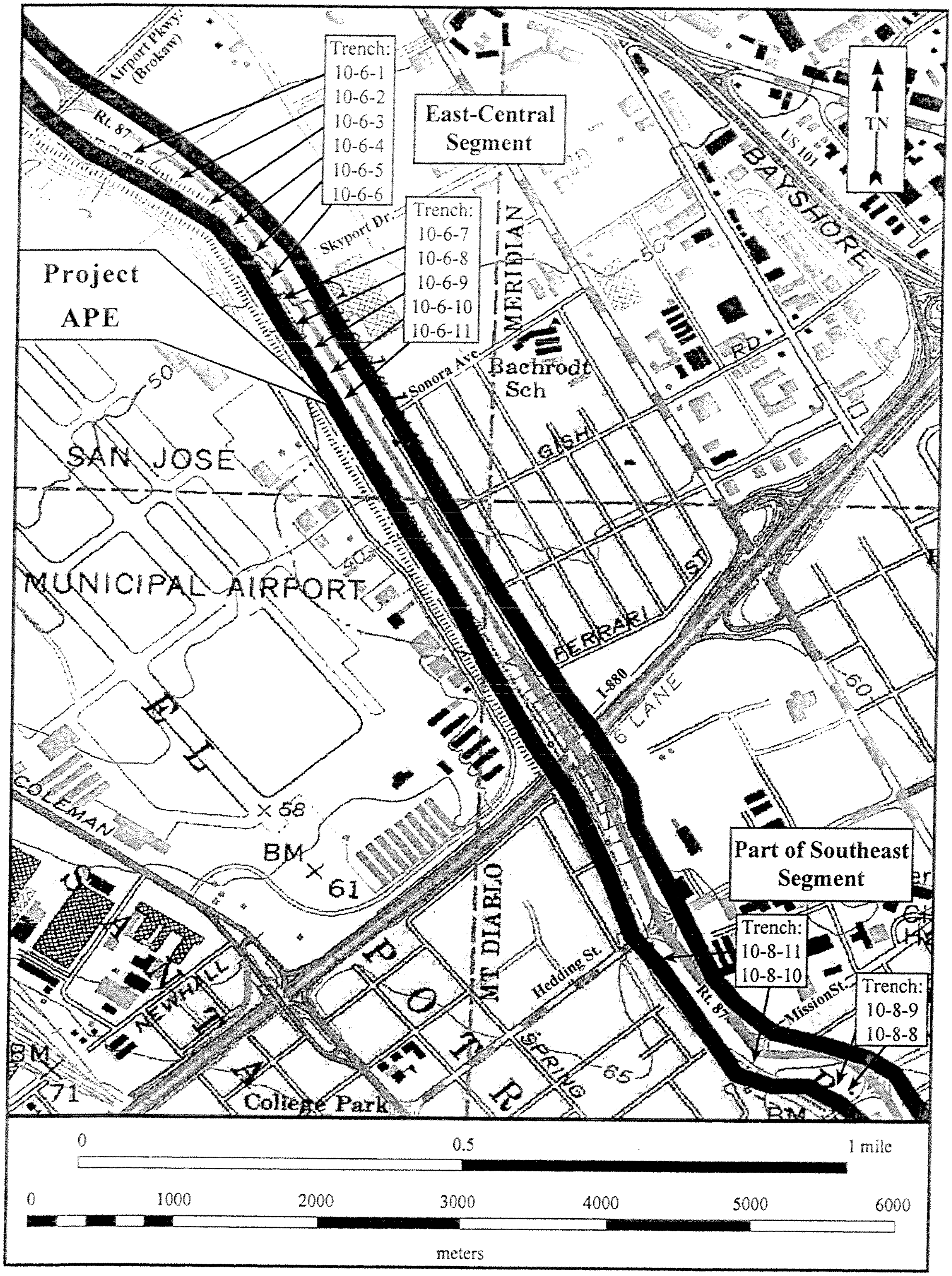


Figure 10. Location of Exploration Trenches in the East-Central and Part of the Southeast Segments

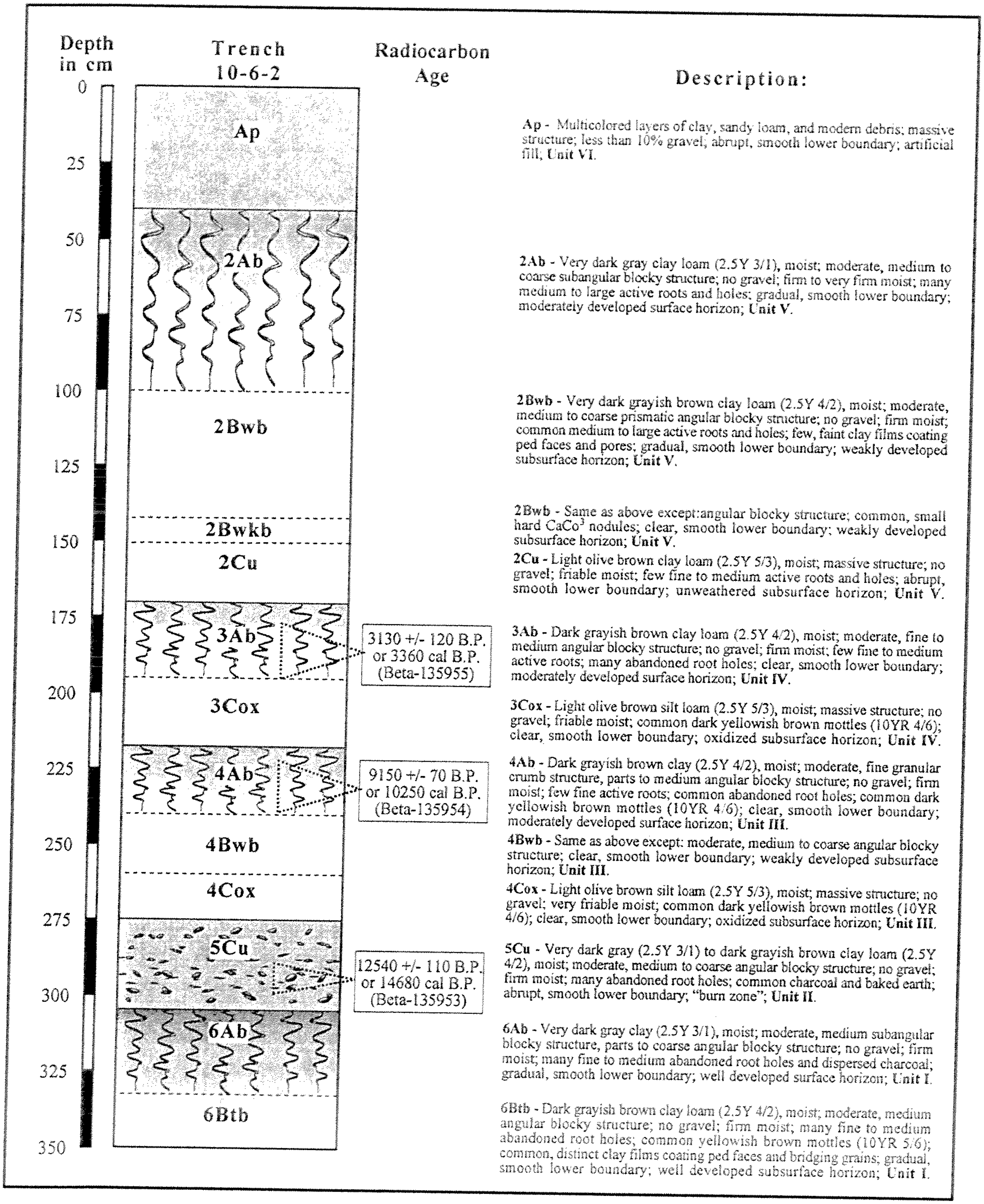


Figure 11. Profile of Soil Stratigraphy Near Airport Parkway

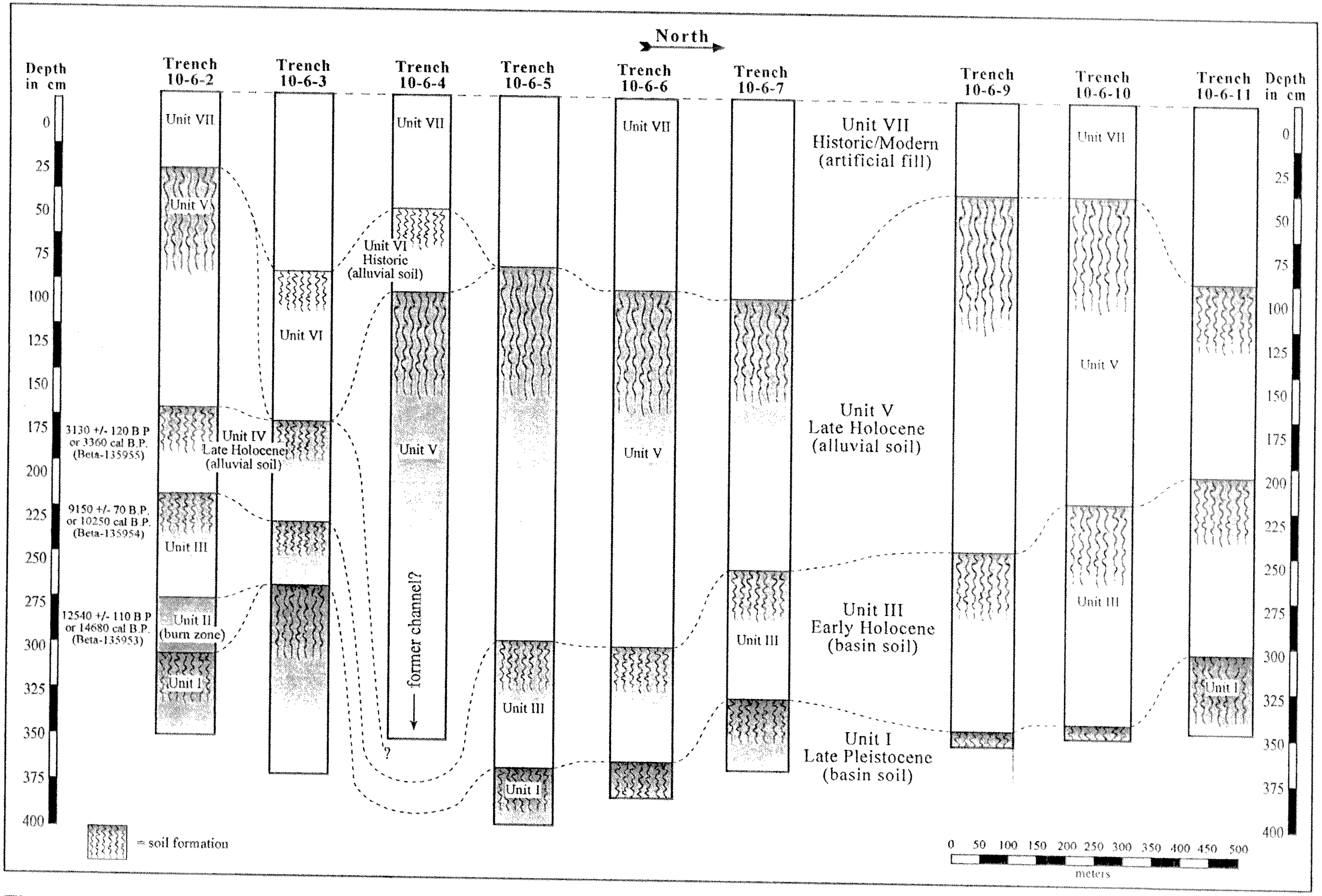


Figure 12. Cross-Section of Stratigraphic Units in the East-Central Segment. Note that trench widths are not to scale.

Unit IV consists of dark grayish brown clay loam that grades downward into light olive brown silt loam (Figure 11). The unit exhibits a dark surface horizon (3Ab), and an unweathered subsurface horizon (3Cu), indicative of a weakly developed soil profile. The upper boundary of the unit was found to occur at a minimum depth of 1.65 m (Trench 10-6-2), and a maximum depth of about 1.7 m (10-6-3). The lower boundary of the unit extended to a maximum depth of 2.35 m below surface (10-6-3). The unit was found to be horizontally restricted in northern part of the segment, suggesting that deposition occurred in or near an active channel (Figure 12).

A radiocarbon date of 3130 ± 120 B.P. or 3360 cal B.P. (Beta-135955) was obtained from a soil sample collected at a depth of 170 to 190 cm within Unit IV (Table 5). No archaeological materials were identified in the unit. Given the stratigraphic and radiocarbon evidence, it appears that Unit IV is an alluvial soil that represents an episode of channel deposition and subsequent floodplain stability that occurred during the Late Holocene.

Unit V consists of very dark gray clay loam that grades downward into light olive brown clay loam (Figure 11). The unit exhibits a thick surface horizon (2Ab), a weakly structured subsurface horizon (2Bwb), a thin subsurface horizon of pedogenic carbonate (2Bwkb), and an unweathered subsurface horizon (2Cu), indicative of a weak to moderately developed soil profile. The upper boundary of the unit was found to occur at a minimum depth of 0.4 m (Trench 10-6-2), and a maximum depth of more than 1.1 m (10-6-4, 10-6-7). The lower boundary of the unit extended to a maximum depth of 3.5 m below surface (10-6-4). The unit was not found to occur in Trench 10-6-3, suggesting it was removed by channel erosion at that location (Figure 12). Based on the stratigraphic and radiocarbon evidence, it appears that Unit V is an alluvial soil that represents an episode of deposition and subsequent floodplain stability that occurred during the Late Holocene to Historic period.

Unit VI consists of brown silt loam that grades downward into brown sandy loam, with a layer of fine sand near its base. The unit exhibits a thin surface horizon and an unweathered subsurface horizon that are indicative of a weakly developed soil profile. The upper boundary of the unit was found to occur at a minimum depth of 0.6 m (Trench 10-6-4), and a maximum depth of about 0.9 m (10-6-3). No archaeological materials were identified in the unit. The unit was found to be horizontally restricted in northern part of the segment, suggesting that deposition occurred in or near an active channel (Figure 12). Based on the stratigraphic evidence, it appears that Unit IV is an alluvial soil that represents an episode of channel deposition and a brief period of floodplain stability that occurred during the Historic period.

Unit VII consists of multicolored layers of alternating clay, sandy loam, gravelly clay loam, and modern construction debris. The lower boundary of the unit was found to extend to a minimum depth of 0.5 m (Trench 10-6-9, 10-6-10), and a maximum depth of 1.1 m (10-6-7). The unit represents disturbed and/or artificial materials that have been deposited and/or mechanically distributed across the segment. It appears that Unit VII is modern or recent in age.

Southeast Segment (Hedding to Hobson Street)

Exploration of the southeast segment was conducted in accessible areas along the eastside of the Guadalupe River, within the project APE between Hedding Street and Hobson Street. Proposed project impacts in this segment include excavating a portion of the eastern Guadalupe River bank for riparian mitigation, and the excavation of an underpass at Taylor Street. At least 300 m3 of deposits were excavated from 25 trenches located in the segment (see Figure 10 and Figure 13). As a result, a previously unidentified prehistoric archaeological site (CA-SCL-829, "Taylor Street Site") was discovered within the segment. Trench 10-7-1 was selected for detailed description because it contained deposits that were representative of the deposits exposed in the majority of the other trenches, and Trench 10-7-11 (also Trench A) was also selected because it contained a concentration of buried archaeological materials. In addition, five radiocarbon dates were obtained from materials collected from the side-walls of Trench 10-7-1. An examination of the exposed deposits resulted in the identification of seven stratigraphic units, which are described below.

Stratigraphic Units

Unit I consists of a black clay loam that exhibits a dark surface horizon (6Ab) and many abandoned root holes indicative of a well-developed soil (Figure 14). The upper boundary of the unit was found to occur at a minimum depth of about 4.0 m (Trench 10-8-8) north of Taylor Street, and a maximum depth of 4.7 m (10-7-1) south of Taylor Street. The lower boundary of the unit extended to a depth of more than 4.8 m below surface (10-8-10), north of Taylor Street. No archaeological materials were identified in the unit. Although no subsurface soil horizons were exposed, the unit's loamy texture and stratigraphic position suggests that it is an alluvial soil.

A radiocarbon date of 11600 ± 110 B.P. or 13735 cal B.P. (Beta-135957) was obtained from a soil sample collected at a depth of 470 to 480 cm within Unit I (Table 5). A sample of the soil was also submitted for pollen analysis, however, no pollen grains were identified. Given the stratigraphic and radiocarbon evidence, it appears that Unit I is an alluvial soil that represents a period of Late Pleistocene floodplain stability.

Unit II consists of a gray silty clay loam that exhibits a very thin surface horizon (5Ab), and an unweathered subsurface horizon (5Cu) (Figure 14). The unit was found to contain a concentration of carbonized plant remains. No archaeological materials were identified. It appears that the unit represents a relatively rapid episode of sediment deposition that was followed by the growth and burial of numerous plant remains. This unit was also identified in Trench E (Figure 13), and the trenches located between Taylor and Mission streets (Figure 10).

A radiocarbon date of 9440 ± 90 B.P. or 10680 cal B.P. (Beta-135958) was obtained from a sample collected at a depth of 440 to 450 cm within Unit II (Table 5). A sample of the sediment submitted for pollen analysis was found to contain a few pollen grains. The identifiable grains were from members of the Asteracea (sunflower) family, and pine (*Pinus*) genera. Unfortunately, the sample did not yield a sufficient number of grains for a statistically meaningful count or comparative analysis. Given the stratigraphic and radiocarbon evidence, it appears that Unit II is an alluvial soil that represents relatively rapid deposition, plant growth, and subsequent burial during the Early Holocene (see below).

Unit III consists of gray clay loam that grades downward into yellowish brown silt loam. The unit exhibits a dark surface horizon (4Ab), a structured subsurface horizon of illuvial clay (4Btb), and an oxidized subsurface horizon (4Cox), indicative of a moderately developed soil profile (Figure 14). The upper boundary of the unit was found to occur at a minimum depth of 1.9 m (10-7-4, -5, and -6), and a maximum depth of about 2.9 m (10-7-8). The lower boundary of the unit extended to a maximum depth of about 4.5 m below surface (10-7-1). The unit was found

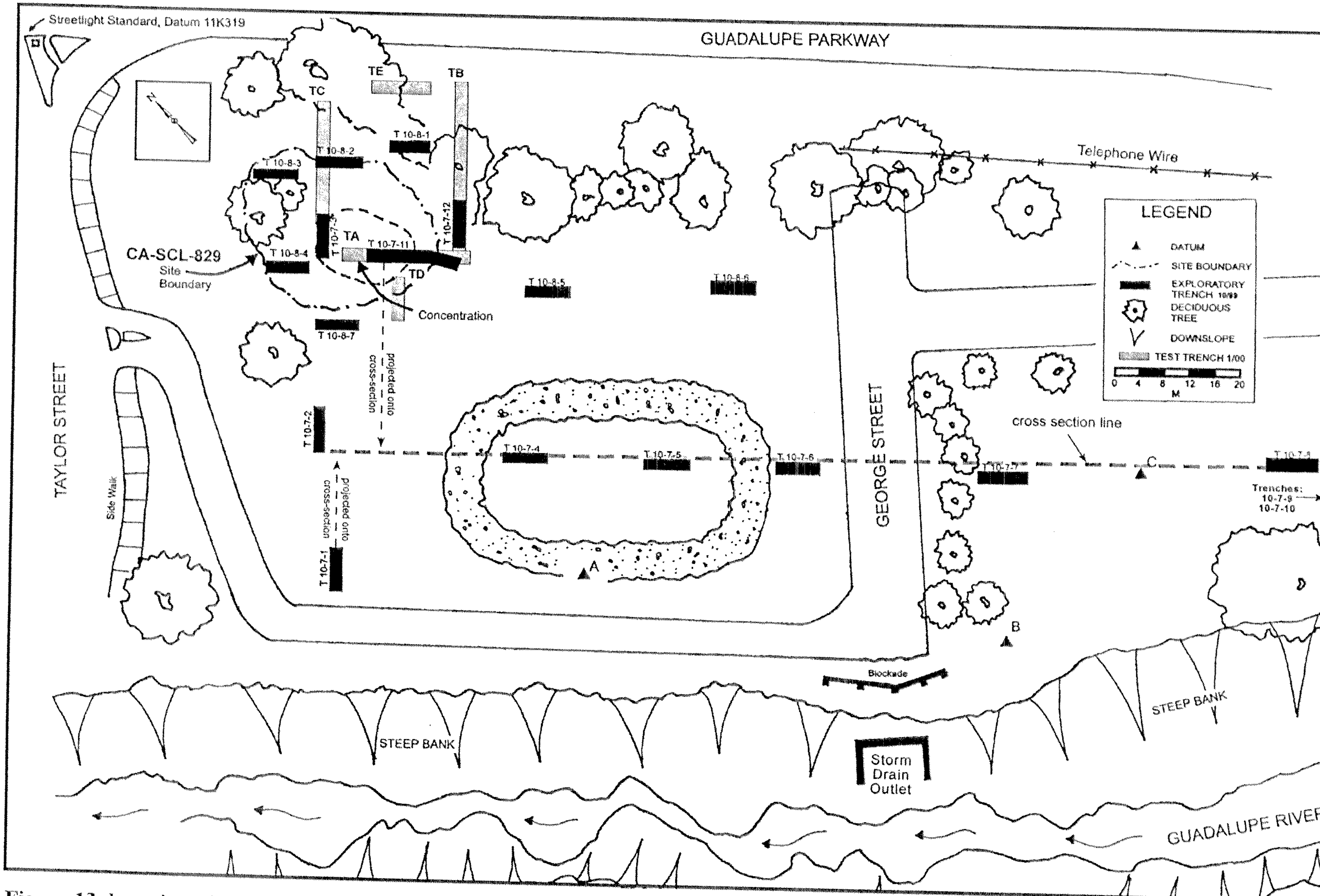
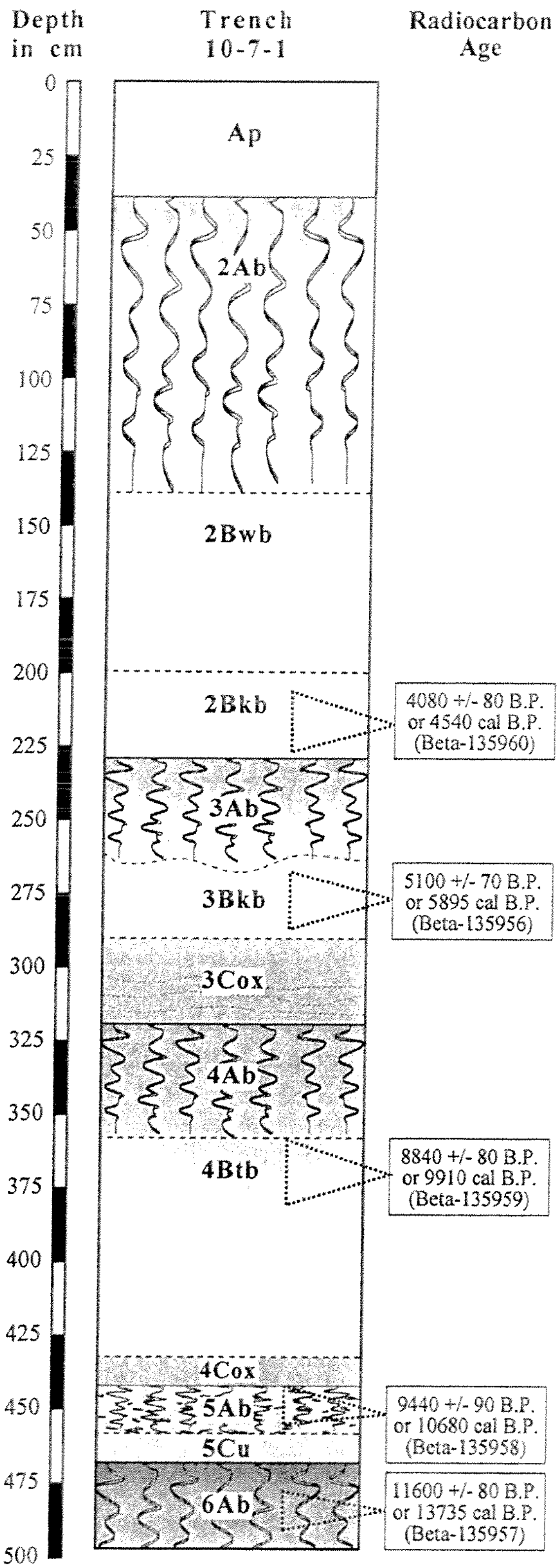


Figure 13. Location of Exploration Trenches Near the Taylor Street Site (CA-SCL-829). Note: cross-section shown in Figure 15.



Description:

Ap - Very dark gray clay loam (10YR 3/2), moist; massive structure; no gravel; common historic debris; very firm moist; clear, smooth lower boundary; artificial fill; **Unit VI**.

2Ab - Very dark grayish brown clay loam (10YR 3/2), moist; weak, medium granular crumb structure, part to coarse subangular blocky structure; no gravel; firm moist; common fine to medium active roots and holes; few dispersed charcoal flecks; gradual, smooth lower boundary; moderately developed surface horizon; **Unit V**.

2Bwb - Brown clay loam (10YR 3/2), moist; strong, coarse prismatic angular blocky structure, parts to medium subangular blocky structure; no gravel; friable moist; few fine to medium active roots and holes; few, faint clay films coating ped faces and bridging grains; gradual, smooth lower boundary; weakly developed subsurface horizon; **Unit V**.

2Bkb - Dark grayish brown silty clay loam (2.5Y 4/2), moist; moderate, coarse prismatic angular blocky structure, parts to same medium; friable moist; few fine active roots and holes; common small, hard $CaCo^3$ nodules; abrupt, smooth lower boundary; unweathered subsurface horizon; **Unit V**.

3Ab - Gray clay loam (2.5Y 5/1), moist; strong, medium to coarse subangular blocky structure, parts to same fine; no gravel; friable moist; many medium to large abandoned root holes; few dark yellowish brown mottles (10YR 4/6); clear, wavy lower boundary; moderately developed surface horizon; **Unit IV**.

3Bkb - Gray clay loam (2.5Y 5/1), moist; strong, medium to coarse subangular blocky structure, parts to same fine; friable moist; many medium to large abandoned root holes; common, small soft $CaCo^3$ nodules; few dark yellowish brown mottles (10YR 4/6); clear, smooth lower boundary; moderately developed subsurface horizon; **Unit IV**.

3Cox - Light yellowish brown silt loam (2.5Y 6/3), moist; moderate, massive structure; very friable moist; common fine to medium abandoned root holes; many dark yellowish brown mottles (10YR 4/6); weakly bedded near base; abrupt, smooth lower boundary; oxidized subsurface horizon; **Unit III**.

4Ab - Gray clay loam (2.5Y 5/1), moist; moderate, medium to coarse angular blocky structure; friable to firm moist; many medium to large abandoned root holes; many dark yellowish brown mottles (10YR 4/6); gradual, smooth lower boundary; moderately developed surface horizon; **Unit III**.

4Btb - Gray clay loam (2.5Y 5/1), moist; moderate, coarse to very coarse prismatic angular blocky structure; friable to firm moist; many fine to medium abandoned root holes; few, distinct clay films coating root holes; gradual, smooth lower boundary; moderately developed subsurface horizon; **Unit III**.

4Cox - Yellowish brown silt loam (10YR 5/6), moist; massive structure; very friable moist; many dark yellowish brown mottles (10YR 4/6); abrupt, smooth lower boundary; oxidized subsurface horizon; **Unit III**.

5Ab - Gray silty clay loam (2.5Y 6/1), moist; weak, medium to coarse angular blocky structure; firm moist; few, medium abandoned root holes; common carbonized "marsh" plant remains; clear, smooth lower boundary; **Unit II**.

5Cu - Gray silty clay loam (2.5Y 6/1), moist; weak, coarse to very coarse subangular blocky structure; firm moist; few, medium abandoned root holes; abrupt, smooth lower boundary; **Unit II**.

6Ab - Black clay loam (2.5Y 5/1), moist; moderate, medium to coarse subangular blocky structure; friable to firm moist; many fine to medium abandoned root holes; common dark yellowish brown (10YR 4/6) coatings in roots holes; well developed surface horizon; **Unit I**.

Figure 14. Soil Stratigraphy West of Taylor Street Site (CA-SCL-829)

in Trench E and in the trenches between Taylor and Mission streets, indicating that it is a laterally extensive deposit (Figure 15).

A radiocarbon date of 8840 ± 80 B.P. or 9910 cal B.P. (Beta-135959) was obtained from a soil sample collected at a depth of 360 to 380 cm within Unit III (Table 5). No archaeological materials were identified in the unit. Given the stratigraphic and radiocarbon evidence, it appears that Unit III is an alluvial soil that represents an episode of alluvial deposition and subsequent floodplain stability that occurred during the Early to Middle Holocene (see date from overlying unit in Figure 14).

Unit IV consists of gray clay loam that grades downward into light yellowish brown silt loam. The unit exhibits a dark surface horizon (3Ab), a well structured subsurface horizon of pedogenic carbonate (3Bkb), and an oxidized subsurface horizon (3Cox), indicative of a moderately developed soil profile (Figure 14). The upper boundary of the unit was found to occur at a minimum depth of 1.1 m (10-7-4, -5, and -6), and a maximum depth of about 2.3 m (10-7-1). The lower boundary of the unit extended to a maximum depth of 3.2 m below surface (10-7-1). The unit found to extend across the entire southeast segment between Hedding and Hobson streets, indicating that it is a laterally extensive deposit (Figure 15).

A radiocarbon date of 5100 ± 70 B.P. or 5895 cal B.P. (Beta-135956) was obtained from a soil sample collected at a depth of 265 to 285 cm within Unit IV (Table 5). No archaeological materials were identified in the unit. Given the stratigraphic and radiocarbon evidence, it appears that Unit IV is an alluvial soil that represents alluvial deposition and a period of floodplain stability during the Middle Holocene.

Unit V consists of a very dark grayish brown clay loam that grades downward into brown clay loam and dark grayish brown silty clay loam. The unit exhibits a thick surface horizon (2Ab), a weakly structured subsurface horizon (2Bwb), and a subsurface horizon of pedogenic carbonate (2Bwkb), indicative of a moderately developed soil profile (Figure 14). The upper boundary of the unit was found to occur at a minimum depth of 0.2 m (10-7-4, 5, and -6), and a maximum depth of 1.4 m (10-7-10). The lower boundary of the unit extended to a maximum depth of 2.3 m below surface (10-7-1). The unit was found to extend across the entire southeast segment between Hedding and Hobson streets, indicating that it is a laterally extensive deposit (Figure 15).

A concentration of archaeological materials, including bone fragments, broken cobbles, heat-altered rock, baked earth or clay, and a few flaked-stone artifacts, were found to be associated with Unit V in the area shown in Figure 13 (White and Thomas 1999). The majority of these materials occurred at depths of 115 to 145 cm below surface (Figure 14). The archaeological deposit was designated CA-SCL-829, and was subject of additional archaeological investigations in January 2000 (see York n.d.).

A radiocarbon date of 4080 ± 80 B.P. or 4540 cal B.P. (Beta-135960) was obtained from a soil sample collected from a depth of 210 to 230 cm in the lower part of Unit V (Table 5). In addition, a date of 1420 ± 40 B.P. or 1310 cal B.P. (Beta-143250) was obtained from cultural charcoal collected from a depth of 120 to 130 cm in the upper part of the unit (Table 5). Given the stratigraphic and radiocarbon evidence, it appears that Unit V is an alluvial soil that represents deposition and a period of floodplain stability during the Late Holocene to Historic period.

Unit VI consists of brown silt loam that grades downward into brown sandy loam, with a layer of fine sand near its base. The unit exhibits a thin surface horizon and an unweathered

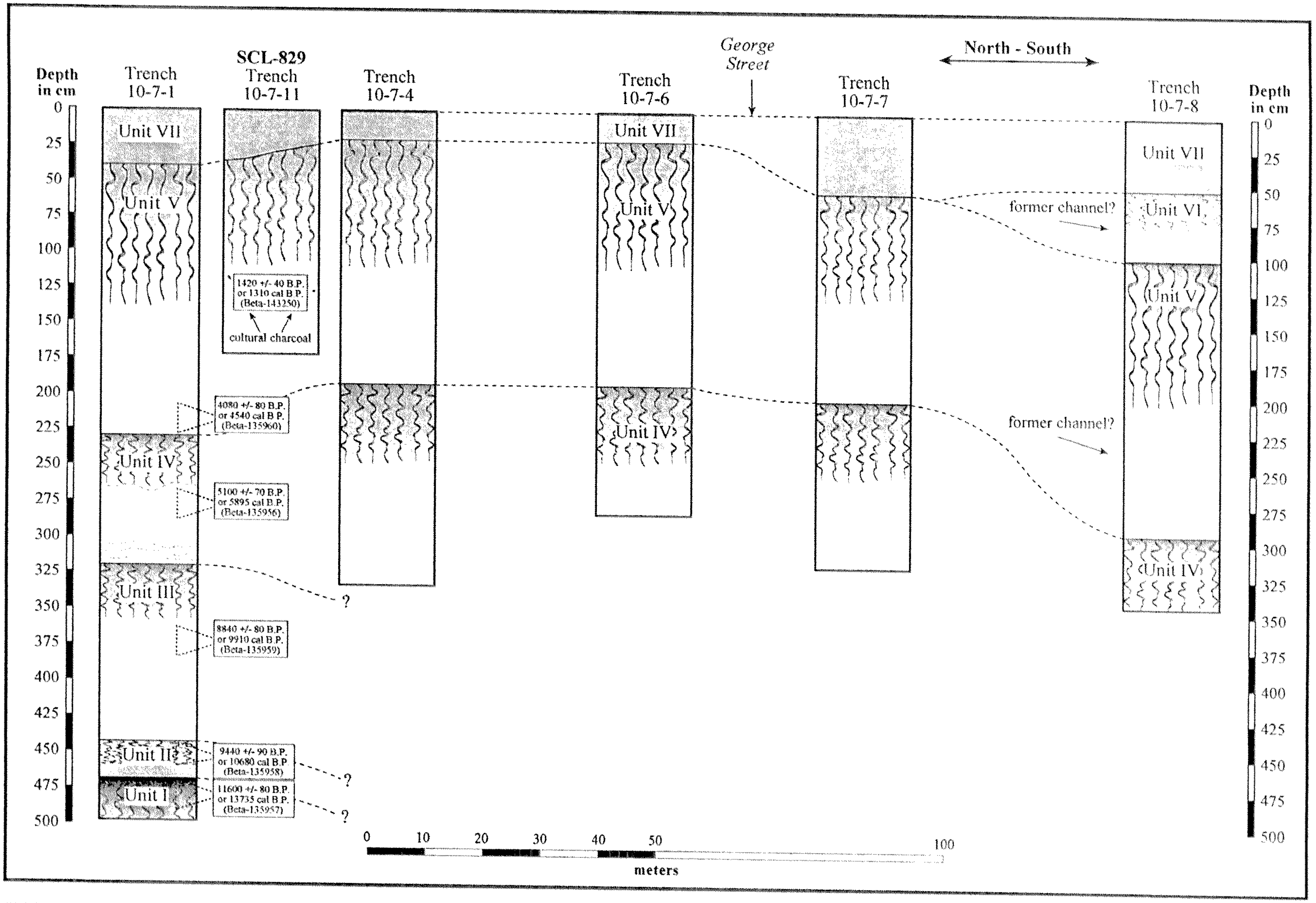


FIGURE 15. Cross-Section of Stratigraphic Units in Part of Southeast Segment. Note that trench widths are not to scale.

subsurface horizon that are indicative of a weakly developed soil profile. The upper boundary of the unit was found to occur at a minimum depth of 0.2 m (Trench 10-7-9), and a maximum depth of about 0.6 m (10-7-10). No archaeological materials were identified in the unit. The unit was found to be horizontally restricted in northern (10-8-11) and southern (10-7-8, -9, -10) parts of the segment, suggesting that deposition occurred in or near an active channel at those locations (Figure 15). A few historic "eastern" oyster shells were recovered from this unit in Trench 10-8-11 (Figure 10). Based on the stratigraphic evidence, it appears that Unit IV is an alluvial soil that represents an episode of rapid channel deposition and a brief period of floodplain stability that occurred during the Historic period.

Unit VII consists of multicolored layers of alternating clay, sandy loam, gravelly clay loam, and historic construction debris. The lower boundary of the unit was found to extend to a minimum depth of 0.2 m (Trench 10-7-4, -5 and -6), and a maximum depth of 0.6 m (10-7-7, and -10). The unit represents disturbed and/or artificial materials that have been deposited and/or mechanically distributed across the segment. It appears that Unit VII is historic to recent in age.

Southwest Segment (Taylor Street Bridge)

A field visit was conducted in the southwest segment in the Taylor Street area on the west-side of the Guadalupe River. Proposed project impacts in this segment include the placement of footings for the proposed Taylor Street bridge. The subsurface deposits in the area were exposed by excavations for a riparian mitigation project being conducted by the Army Corps of Engineers. Two separate buried paleosols (Unit X and Y) were identified in this segment, and samples of each were collected for radiocarbon dating. A soil sample collected from the Unit X paleosol at a depth of 527 to 547 cm below ground surface yielded a radiocarbon date of 6320±70 80 B.P. or 7255 cal B.P. (Beta-130741) (Table 5). A soil sample collected from the Unit Y paleosol at a depth of 627 to 637 cm below ground surface yielded a radiocarbon date of 6700±40 B.P. or 7580 cal B.P. (Beta-130742) (Table 5). The stratigraphic and radiocarbon relationship of these paleosols indicate that landform stability was interrupted by a brief depositional episode during the Early Holocene.

Summary

Subsurface explorations within the project APE resulted in the identification of two buried prehistoric archaeological deposits (CA-SCL-828 and -829), and a sequence of alluvial deposits that span the past 16,000 years. Buried paleosols and evidence of former river channels were identified in each of the three APE segments explored for this study. Stratigraphic and radiocarbon evidence indicates that laterally extensive buried paleosols, dating to the Late Pleistocene, Early Holocene, and Middle Holocene, are present within the APE. Alluvial sediments dating to the Early and Late Holocene and a laterally restricted buried paleosol dating to the Late Holocene were also identified in the APE. A few pollen grains and charred plant remains, useful for reconstructing past environmental conditions, were recovered from these deposits. In addition, disturbed or artificial deposits dating from historic to recent in age deposits were found to extend across the surface of most of the APE. The importance of these findings for understanding the natural stratigraphy, paleoenvironmental changes, and apparent distribution of archaeological sites in and near the project corridor are discussed below.

ANALYSIS AND DISCUSSION

Introduction

The following section provides an analysis of the stratigraphic, radiocarbon, and paleoenvironmental evidence obtained from the project area. The analysis focuses on the paleoenvironmental and archaeological significance of this evidence, particularly as it relates to the problem of archaeological visibility in the APE, and the research issue of human occupation and landscape evolution. Information about the nature, use, and interpretation of radiocarbon dates is provided in *Field and Laboratory Methods*.

Landform Stratigraphy

Analysis of the stratigraphic sequences and radiocarbon ages indicate that there are important differences and similarities in the depositional history of the landform-deposits identified in different parts of the project area. Three main landform-deposits were identified: (1) low-energy basin deposits composed of fine-grained alluvium (clay to clay loam); (2) with moderate-energy floodplain deposits composed of medium-grained alluvium (silty clay loam to silt); and (3) high-energy deposits composed of coarse-grained alluvium (sandy loam to sand and gravel) associated with deposition in or near present or former channels. In addition, disturbed or artificial deposits associated with historic fill were also identified throughout the APE. Thus, the formation of deposits in the project APE is primarily the result of natural alluvial deposition.

A comparison of the stratigraphic sequences in each segment reveals significant differences in the number and age of the stratigraphic units. The number of units ranged from five in the northwest segment to seven in the east-central and southeast segments. Four of the units identified in the northwest segment appear to be historic to recent in age (units II-V), compared with only two of the seven units identified in the eastern segments. Radiocarbon dates indicate that multiple alluvial deposits are present along the eastern side of the river. These deposits include buried Late Pleistocene, Early Holocene, Middle Holocene, and Late Holocene paleosols, and buried Early Holocene and Late Holocene alluvium (Figure 16). Two buried paleosols were also identified in the southwest segment west of the river, both dating to the Early Holocene (Units X and Y in Figure 16). The age of these deposits indicates that there may be considerable variability in the age of different landform-deposits within the project area. At the same time, the deposits identified in the east-central and southeast segments have similar ages and stratigraphic sequences that suggests: (1) that eastern side of river has a similar depositional history; (2) that the stratigraphic units have considerable lateral continuity; and (3) that the stratigraphic sequences may be correlated between different segments.

The nature and extent of the landform-deposits indicates that: (1) basin landforms are generally distributed to the west of the river; (2) alluvial floodplain landforms are distributed to the east of the river; and (3) landforms associated active channels are distributed along the river. The distribution of these landform-deposits is generally consistent with the areas mapped as Holocene floodbasin, floodplain, and natural levee deposits in Figure 2 (Helley et al. 1994). Given that the river serves as a division between the basin and alluvial landform-deposits, it appears overbank flooding resulted in the more rapid, and/or repeated deposition of sediments east of the river, as compared to west of the river. The findings of this study indicate that the basin soils are associated with a few, thick stratigraphic units (northwest and southwest segment), while the alluvial soils are associated with multiple stratigraphic units. Two buried paleosols associated with basin landforms in the southwest segment produced Early Holocene-age radiocarbon dates (Figure 16), indicating that they are generally older and have remained stable for a longer period of time than the alluvial landforms. The apparent stability of the basin landforms is also demonstrated by vertical superposition of the overlying historic levee deposits (Units II and III in the northwest segment), and the relatively recent

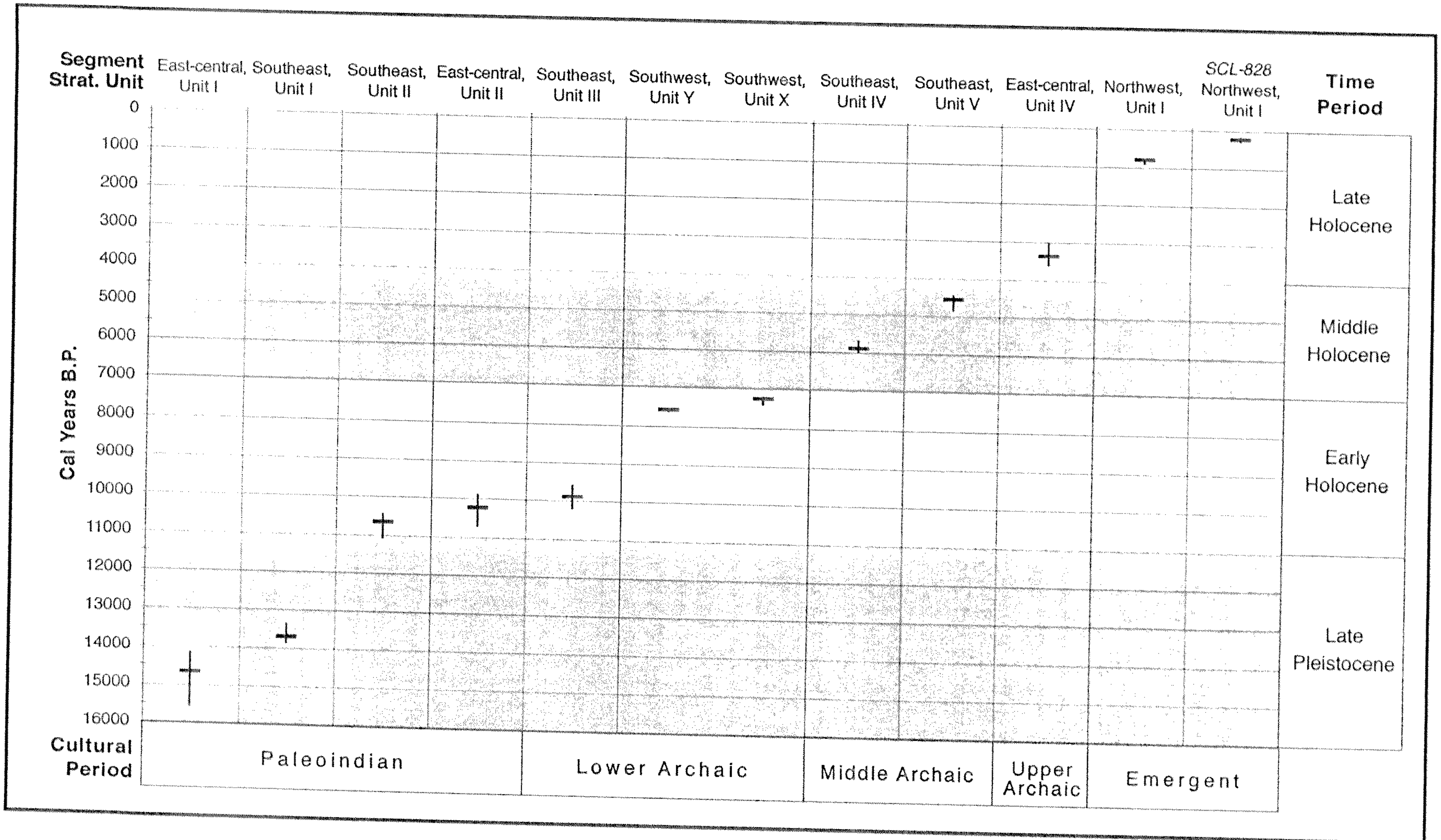


FIGURE 16. Temporal Distribution of Radiocarbon Dates from the Guadalupe Corridor. Horizontal bars indicate intercept with calibration curve. Vertical lines inidcate the upper and lower age range at 2 sigma for soil samples, and 1 sigma for charcoal and shell samples. All dates obtained from natural (non-cultural) contexts except for the date from CA-SCL-828; date of 1310 cal B.P. from CA-SCL-829 not included.

age (255 cal B.P.) of associated archaeological materials (Figure 9). These distinctions suggest that the basin landforms have been available for human use longer than the alluvial landforms, and should, therefore, contain archaeological materials that span a greater temporal range. At the same time, most of the natural levee deposits along the river appear to be less than a few hundred years old, and therefore, have little or no potential for containing evidence of prehistoric human use or occupation.

Paleoenvironment

The stratigraphic, radiocarbon, flotation, and pollen analyses provide some evidence of the former environmental conditions that existed in the project area. This evidence includes: (1) the presence or absence of paleosols as a relative indicator of landform stability; (2) the radiocarbon age of 13C/12C isotope ratios as a proxy indicator of vegetation and climate; (3) the presence of pollen grains as an indicator of general vegetation communities; and (4) the presence of charred plant remains as an indicator of specific plant types.

The stratigraphic evidence demonstrates that the landscape in the project area was formed by multiple cycles of deposition and relative landform stability. Radiocarbon dates obtained from alluvium and buried soils (paleosols) indicate that periods of floodplain stability were repeatedly interrupted by depositional episodes over the past 16,000 years; although the timing and/or extent of these processes varied within different segment of the project area. Alluvium containing numerous charcoal fragments (dated to 14680 cal B.P.) suggests that fires may have been more common during the Late Pleistocene (see "burn zone" Figure 11). It appears that much of the project area underwent a prolonged period of floodplain stability during the Early Holocene (Figure 17), which may reflect better-drained floodplain conditions that probably existed when sea levels were lower. Evidence of increased channel aggradation, widespread floodplain deposition, and shorter periods of land stability are found in the Middle and Late Holocene-age identified along the eastern side of the river; a particularly thick package of floodplain alluvium began to be deposited in the southeast segment during this time. These changes were likely in response to higher sea levels at the mouth of the Guadalupe River, and possibly the greater environmental variability associated with the Middle Holocene (West 1993). Finally, rapid channel aggradation and levee building occurred along the banks of the Guadalupe during the past few hundred years. This deposition may be in response to: historic overgrazing and the replacement of native plants by introduced species (Burcham 1982), and/or widespread subsidence of the valley due to rapid groundwater-withdraw (Poland and Ireland 1988).

Carbon isotope (13C/12C) ratios were obtained from samples collected from the project area as part of the radiocarbon analysis. As described in the *Field and Laboratory Methods* section above, these ratios are proxy indicators of past environments because various plants have distinctive 13C/12C ratios that correspond to warmer/drier and cooler/moister growing conditions. Lower temperatures and regular moisture conditions favor the growth of 3C plants (ratios between -33 to -22‰), while higher temperatures and restricted moisture conditions favor the growth of 4C plants (ratios between -16 to -9‰). At the same time, isotope ratios can vary within both plant types in response to stressful or favorable environmental conditions (Comstock no date). Thus, variations in the 13C/12C ratio can be used to monitor environmental changes in 3C and 4C plants over time.

Figure 17 shows that the 13C/12C ratios obtained from soil, sediment, and charcoal samples in the project range from 22.8 to 26.3‰ (mean = -24.6, STD = 1.1). While these ratios are well within the range associated with cooler/moister 3C plants, the ratios show a strong trend from higher to lower negative ratios, suggesting that the growing conditions for these plants became more favorable (cooler and/or moister) over the past 16,000 years. The trend from warmer and/or drier to cooler and/or moister conditions may be related to higher groundwater levels in response to sea level rise in and around San Francisco Bay. This may explain why the 13C/12C evidence stands in contrast to

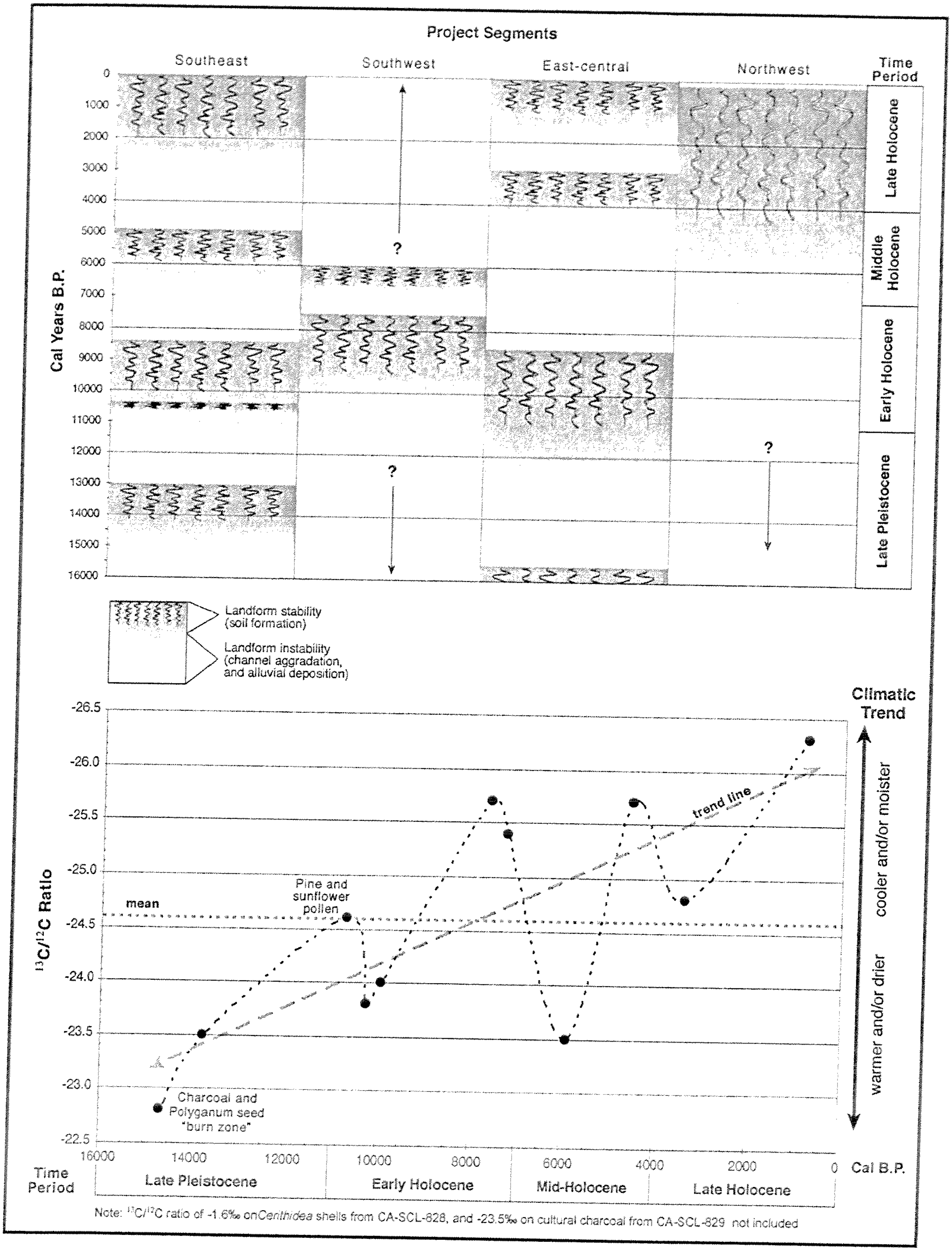


FIGURE 17. Temporal Distribution of Paleoenvironmental Indicators from the Project Area

evidence from surrounding regions for cooler and/or wetter conditions during the Late Pleistocene (West 1993). At the same time, the ratios varied significantly from –25.7‰ in the Early Holocene to -23.5‰ in the Middle Holocene, then rebounding to –25.7‰ in the latter part of the Middle Holocene - a variation of 2.2‰ over a period of about 3,000 years (Figure 17). This fluctuation may signal a period of greater environmental variability, and possibly warmer and/or drier conditions during the Middle Holocene.

The analyses of pollen and flotation samples indicate that certain plant types were present in or near the project area. A charred seed identified as Dock or Knotweed *(Polyganum)* was recovered from Late Pleistocene alluvium, which also contained numerous charcoal fragments. Pollen grains identified as members of the sunflower (Asteraceae) and pine (*Pinus*) families were recovered from an Early Holocene-age soil. According to West, "the Asteracea grains are undoubtedly locally derived and the two pine grains could be from upland trees, since pine pollen grains can be readily transported long distances by wind" (Appendix C of this report). Charred plant remains representing California Bay or Laurel nut *(Umbellularia californica)* and seeds of the Poaceae family were recovered from Late Holocene deposits at prehistoric archaeological site SCL-828. It is interesting to note that SCL-828 is located in an area that was historically known as "Laurel Wood Farm" (Thompson and West: 1876). In addition, the faunal remains recovered from SCL-828 (*Cerithidea* shell) and SCL-829 (deer mandible) indicate the occurrence of certain animal species and their associated habitats.

These indicators provide a basis for understanding certain paleoenvironmental conditions in the project area, and changes in these conditions over time. The stratigraphic analysis has shown that alternating cycles alluvial deposition and floodplain stability produced different depositional histories in different parts of the project area. Early and Middle Holocene floodplains have been largely buried by Late Holocene and Historic period alluvium. Carbon isotope ratio analysis indicates a trend from warmer and/or drier conditions during the Late Pleistocene to cooler and/or moister conditions during the Late Holocene, and a period of greater environmental variability during the Middle Holocene. The identity of certain plants and animals, that lived in or near the project area, was also confirmed. Taken together, the evidence suggests that the project area has undergone a series of paleoenvironmental changes that have altered the landscape, and which likely affected human settlement and subsistence activities.

Archaeological Visibility and Landscape Evolution

This section evaluates the relationship between landscape evolution on prehistoric human occupation and archaeological visibility in the project area. The fundamental connection between human occupation and landscape evolution is the observation that human activities have been, and are still, primarily associated with stable landforms. Soil formation is interpreted as evidence of land stability and the availability of landforms for human use, while erosion and deposition are interpreted as evidence of land instability and the unavailability of landforms. Further, landforms with well-developed soil profiles have been stable, and therefore, available for human use and occupation, longer than landforms with weakly developed soil profiles.

The findings of this study show that the project area has undergone a series of significant landscape changes, ranging from prolonged periods of landform stability and soil formation, to major depositional episodes that simultaneously buried large segments of the Guadalupe River floodplain with alluvium. The timing and extent of these processes were found to vary in different parts of the project area, particularly east of the river. Thus, there has been a differential influence of landscape evolution on human occupation and archaeological visibility within the project area.

Late Pleistocene landform-deposits with well-developed paleosols were identified in two of the project's five segments. These paleosols (Unit I) were found to occur at a depth of more than 3.0

m in east-central segment, and nearly 5.0 m in the southern segment. Both of these paleosols were buried by alluvial deposition more than 11,000 years ago (Figure 16). Although no archaeological materials were recovered from these paleosols, they may contain evidence of human use during the Paleoindian period.

Early Holocene landform-deposits with weakly and moderately developed paleosols were identified in the project area. These paleosols were found to occur at depths of more than 2 m in the east-central segment (Unit III) and at depth of more than 3.0 to 4.0 m in the southeast segment (Unit II and III). In addition, two separate buried Early Holocene paleosols were identified at depths of 5.3 and 6.3 m below surface in the project's southwest segment. The lower of the two paleosols in the southeast segment is weakly developed, reflecting only a few hundred years of land stability. The upper of the of the two paleosols in the southeast segment is moderately developed, and was buried about 6,000 years ago, reflecting about 4,000 years of stability. The paleosol in the east-central segment is moderately developed, and was buried about 3,400 years ago, thus reflecting about 7,000 years of land stability prior to burial (Figure 17). These differences indicate that there is a greater potential for buried archaeological resources associated with the moderately developed paleosols than the weakly developed paleosol. While no archaeological materials were recovered from these paleosols, they may contain evidence of human use during the Paleoindian and Lower Archaic periods.

Middle Holocene landform-deposits with moderately to well developed paleosols were identified in the project area. These landforms were found to occur at a depth of about 2.3 m in the southeast segment (Unit IV) and at depths of 1.5 to more than 3.0 m in the northwest segment (Unit I). The paleosol in the southeast segment is moderately developed, and was buried more than 4,500 years ago, reflecting about 1,500 years of stability. The paleosol in the northwest segment is well developed, and was buried during the past few hundred years or less, thus reflecting approximately 5,000 years of land stability prior to burial (Figure 17). These differences indicate that there is a greater potential for buried archaeological resources associated with the well-developed paleosol in the northwest segment than the moderately developed paleosol in the southeast segment. No archaeological materials were recovered from the paleosol in the southeast segment, however, archaeological materials (CA-SCL-828) dating to the Emergent period (255 cal B.P.) were recovered from the paleosol in the northwest segment. As such, the northwest paleosol may contain evidence of human use that ranges from the Middle Archaic to Historic periods, while the southeast paleosol may contain evidence of only Middle Archaic human use.

Late Holocene landform-deposits with weakly to moderately developed paleosols were identified in the project area. These landforms were found to occur at a depth of about 1.7 m in the east-central segment (Unit IV), and just beneath a layer of artificial fill in the east-central and southeast segment (Unit V). The paleosol in the east-central segment is moderately developed, and was buried sometime after 3,400 years ago, reflecting about 1,000 to 2,000 years of stability. The paleosol in the southeast segment is moderately developed, and was formed sometime after 4,500 years ago, thus reflecting approximately 4,000 years of land stability (Figure 17). These differences indicate that there is a greater potential for buried archaeological resources associated with the paleosol in the southeast segment than the paleosol in the east-central segment. No archaeological materials were recovered from the paleosol in the east-central segment, however, archaeological materials (CA-SCL-829) were recovered from the paleosol in the southeast segment (the age of these materials has not yet been determined). As such, the east-central paleosol may contain evidence of human use during the Middle and Upper Archaic periods, while the southeast paleosol may contain evidence of human use during the Middle Archaic to Historic periods.

These findings demonstrate that the project area is composed of multiple landform-deposits of different ages that were variously available for human use or occupation between the Late Pleistocene and Historic period. These landform-deposits exhibit extensive lateral continuity, but are horizontally restricted within the project area. The depositional history of these deposits indicates that several formerly stable landforms have been buried by multiple episodes of alluvial deposition over the past 16,000 years. Given the likely association between human activities and stable landforms, it appears that landscape evolution has exerted a strong influence the visibility of the archaeological record within the project area. The estimated age and approximate depth and these buried landforms are summarized in Table 6 for different segments of the project area.

TABLE 6. AGE AND DEPTH OF PREHISTORIC LANDFORM-DEPOSITS

	Unit 1		**Unit II**		**Unit III**		**Unit IV**		**Unit V**	
Segment	*Age ka*	*Depth meters*	*Age ka*	*Depth meters*	*Age ka*	*Depth meters*	*Age ka*	*Depth meters*	*Age ka*	*Depth meters*
Southeast	11-14	>4.6	10-11	>4.4	6-10	>3.1	4.5-6	>2.0	<4.5	.2-1.7
Southwest	7.4-8	>6.3	7.3-7	>5.3	-	-	-	-	-	-
East-central	>15	>3.0	11-14	2.7-3	3.6-11	>2.0	<3.6	>1.6	<2?	.3-1.5
Northwest	.2-5	1.5-3	<0.2	1–1.5	-	-	-	-	-	-

Note: Age ka times 1,000 years

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FINDINGS AND CONCLUSIONS

Introduction

Subsurface geoarchaeological explorations were conducted in the project area to: (1) identify and document the natural landform-deposits; (2) search for potentially buried archaeological materials; and (3) evaluate and refine the sensitivity assessment for estimating the potential for buried archaeological sites. Recognizing the problem of poor archaeological visibility in the Santa Clara Valley, Caltrans archaeologist, Mark Hylkema, requested a geoarchaeological study of the project corridor as part of the HPTP (Allen et al. 1999). The initial study provided estimates of the potential for buried archaeological resources for different segments of the project corridor, based primarily on previous archaeological, geological, and radiocarbon studies (Meyer 1999). The assessment recommended the use of a geoarchaeological landscape approach to reduce the area and/or volume of deposits to be searched and/or monitored, and thereby, increase the likelihood that potentially buried archaeological resources would be identified. Two buried prehistoric archaeological deposits were discovered as a result of the subsurface explorations.

The assessment identified two major landform-deposits, consisting of younger alluvial soils (east of the river), and older basin soils (west of the river), in the project APE, and historic-age deposits along the river. Based on an analysis of sites located within 2.5 miles of the APE, it was found: (1) that Middle and Upper Archaic period archaeological sites are almost exclusively associated with the basin landforms; (2) that sites dating from the Late Middle period Transition to Middle Phase 1 of the Emergent period are associated with both landform-deposits; and (3) that sites that date to less than 700 years (Late Phase 1 and Phase 2 of the Emergent period) are associated exclusively with alluvial landforms. It was determined: (1) that most buried sites occur where alluvial soils are mapped at the surface, and (2) that the chance of encountering a buried site is greatest in areas where alluvial landforms to overlie basin landforms. Using these and other distinctions, large segments of the project APE were estimated to have a moderate to high potential for buried archaeological resources, and geoarchaeological explorations were recommended for those segments (Meyer 1999).

Data Requirements and Findings

The identification and recovery of certain types of data from the project area was a research requirement for addressing the issue of landscape evolution and human occupation (Allen et al. 1999:138). This section reviews the original research requirements or "data needs" (in italics below), and compares these with the findings of the current study.

> *1. Project area deposits with the potential to yield, datable geological deposits and/or evidence of paleoenvironmental changes that contributes to an understanding of the timing and extent of Holocene landscape evolution and human occupation.*

The findings of this study demonstrate that the project area is composed of multiple landform-deposits that were formed by alternating cycles of deposition and relative landform stability. The landform-deposits included: (1) low-energy basin deposits composed of fine-grained alluvium (clay to clay loam); (2) with moderate-energy floodplain deposits composed of medium-grained alluvium (silty clay loam to silt); (3) high-energy deposits composed of coarse-grained alluvium (sandy loam to sand and gravel) associated with deposition in or near present or former channels; and (4) disturbed or artificial deposits associated with historic fill. The nature and extent of these deposits indicates that: (1) basin landforms are generally distributed to the west of the river; (2) alluvial floodplain landforms are distributed to the east of the river; and (3) landforms associated with active channels are distributed along the river.

The landform-deposits also yielded a variety of datable materials including bone, shell, charcoal, and soil humates. Radiocarbon dates obtained from alluvium and buried soils (paleosols) indicate that periods of floodplain stability were repeatedly interrupted by depositional episodes over the past 16,000 years (Figure 17).

Paleoenvironmental indicators included: (1) alluvial stratigraphic sequences that indicate relative landform stability or instability; (2) carbon isotope (13C/12C) ratios that are a proxy indicator of vegetation and climate; (3) a few pollen grains as an indicator of general vegetation communities; and (4) the presence of charred plant remains as an indicator of specific plant types. The paleoenvironmental evidence indicates that: (1) conditions may have been warmer and/or drier during the Late Pleistocene; (2) a period of prolonged floodplain stability occurred during the Early Holocene; (3) increased channel aggradation, widespread floodplain deposition, and shorter periods of land stability occurred during the Middle and Late Holocene-age, and (4) rapid channel aggradation and levee building occurred along the banks of the Guadalupe during the past few hundred years (Figure 17).

These indicators provide a basis for understanding certain paleoenvironmental conditions in the project area, and changes in these conditions over time. The stratigraphic analysis has shown that alternating cycles of alluvial deposition and floodplain stability produced different depositional histories in different parts of the project area. Early and Middle Holocene floodplains have been largely buried by Late Holocene and Historic period alluvium. Carbon isotope ratio analysis indicates a trend from warmer and/or drier conditions during the Late Pleistocene to cooler and/or moister conditions during the Late Holocene, and a period of greater environmental variability during the Middle Holocene. Taken together, the evidence suggests that the project area has undergone a series of paleoenvironmental changes that altered the landscape, and which likely affected human settlement and subsistence activities. As such the findings represent a significant advance in our understanding the nature, timing, and extent of past environmental conditions that may have influenced human use and/or occupation of the project area.

2. Project area deposits representing distinctive Holocene-age landform-deposits (marked by buried paleosols) that can be traced laterally across the APE in search buried prehistoric archaeological resources?

A comparison of the stratigraphic sequences in each segment reveals significant differences in the age and occurrence of identified landform-deposits. These deposits include buried Late Pleistocene, Early Holocene, Middle Holocene, and Late Holocene paleosols, and buried Early Holocene and Late Holocene alluvium. Two buried paleosols were also identified in the southwest segment west of the river, both dating to the Early Holocene (Table 5). The age of these deposits indicates that there may be considerable variability in the age of different landform-deposits within the project area (Figure 17). At the same time, the deposits identified in the east-central and southeast segments have similar ages and stratigraphic sequences that suggests: (1) that eastern side of river has a similar depositional history; (2) that the landform-deposits have considerable horizontal continuity; and (3) that the stratigraphic sequences may be correlated between different segments. Thus, the project area was found to contain distinctive Holocene-age landform-deposits that were traced laterally across the APE in search of buried sites. Two buried prehistoric archaeological deposits were identified as a result.

3. Project area deposits useful for determining if the comparative lack of early and Middle Archaic period sites in the Guadalupe River floodplain is the result of cultural settlement patterning or natural landscape evolution?

The sensitivity assessment suggested that the apparent lack of Upper Archaic period sites associated with alluvial landforms is not merely a product of cultural patterning, but a reflection of the comparative age and stability of the basin and alluvial landforms. This study found that the basin soils are associated with a few, thick stratigraphic unit (northwest and southwest segment), while the alluvial soils are associated with multiple stratigraphic units. Two buried paleosols associated with basin landforms in the southwest segment produced Early Holocene-age radiocarbon dates (Table 5), indicating that they are generally older and have remained stable for a longer period of time than the alluvial landforms. The apparent stability of the basin landforms is also demonstrated by vertical superposition of the overlying historic levee deposits, and the relatively recent age (255 cal B.P.) of associated archaeological materials.

These distinctions suggest that the basin landforms have been available for human use longer than the alluvial landforms, and should, therefore, contain archaeological materials that span a greater temporal range (Figure 17). As such, the northwest paleosol may contain evidence of human use that ranges from the Middle Archaic to Historic periods, while the southeast paleosol may contain evidence of only Middle Archaic human use. This finding suggests that the comparative lack of sites greater than 2,500 years old may be a byproduct of Holocene landscape evolution, particularly east of the river.

4. Project area deposits bearing evidence of large-scale landscape evolution that contributes to an understanding of the apparent abandonment and/or relocation of prehistoric settlements on the Guadalupe River floodplain around 1,500 years ago.

This study found little direct evidence of large-scale landscape evolution around 1,500 years ago. However, a Late Holocene-age paleosol was identified in the East-central segment of the project area (Figure 11), at a depth of about 1.7 m below surface (Unit IV). Radiocarbon dating indicates that the paleosol was buried less than 3,400 years ago (Table 5). Based on the degree of soil development in the overlying deposits, it appears that this paleosol may have been buried during the past 1,500 to 2,500 years ago. Thus, it is possible that this paleosol may contain buried evidence of human use during the Middle and Upper Archaic periods that may contribute to an understanding of human use and/or occupation along the Guadalupe River around 1,500 years ago. At the same time, it is possible that such evidence is present outside of the project APE, particularly in the more northern parts of the floodplain.

5. Project area deposits supplying evidence that paleoenvironmental changes caused significant fluctuations in the availability and/or productivity of local resources that were responsible for transitions in human subsistence activities and/or settlement patterns, particularly around 1,500 years ago.

Evidence of large-scale paleoenvironmental changes 1,500 years ago was not identified by this study. However, a radiocarbon date from the Late Holocene-age paleosol in the East-central segment indicates that a period of relative landform stability around 3,400 years ago was followed by a significant episode of deposition during the Late Holocene. In addition, carbon isotope ratios suggest that environmental conditions may have become generally cooler and/or moister during the Late Holocene (Figure 17). Thus, it is possible that that the project APE contains evidence useful for determining if human settlement and subsistence patterns were affected by resource fluctuations that were caused by paleoenvironmental change around 1,500 years ago. It is also possible that such evidence is present outside of the project APE, particularly in the more northern parts of the floodplain.

Conclusions

The project area was found to contain a sufficient quantity and variety of data for addressing the important research issue of human occupation and landscape evolution. The project area has undergone a series of significant landscape changes over the past 16,000 years, ranging from prolonged periods of landform stability (soil formation), to major episodes of alluvial deposition. While the timing and extent of these processes has varied in different parts of the project area, they have generally resulted in the burial of landforms that were available for human use and occupation between the Late Pleistocene and Historic period. Former habitable landforms are represented by buried soils (paleosols) that exhibit extensive horizontal continuity, but are laterally restricted within the project area. It was determined that the landforms located west of the river have generally been more stable than landforms located east of the river, however, levee deposits have buried portions of these landforms along both sides of the river during the past few hundred years.

Together, this evidence demonstrates that landscape evolution has exerted a strong influence on the visibility of the archaeological record in the project area, confirming that the APE possesses considerable potential for containing buried prehistoric archaeological resources. Thus, the apparent presence or absence of surface sites is by no means a full reflection of prehistoric human population and/or settlement patterns in the project area. Instead, accurate interpretation of these patterns will require that the influence of both natural and cultural processes be evaluated in terms of differential landscape evolution over time. For these reasons it is recommended that an appropriate archaeological monitoring program be implemented to anticipate the discovery of additional buried archaeological deposits within sensitive segments of the project corridor. Such a program should consider the age, depth, and extent of the buried land surfaces (see Table 6), and the potential effects of project-related earth disturbing activities. Based on this study, earth disturbances that extend to a depth of 5.0 meters below surface should be monitored for archaeological materials along most of the project corridor, and to a depth of about 7.0 m in the project's southwest segment. Finally, future archaeological studies in the area should consider the potential effects of landscape changes on the visibility of archaeological deposits and the nature and completeness of the archaeological record in the Guadalupe River floodplain.

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APPENDIX A

Radiocarbon Dating Methods and Results

BETA ANALYTIC INC.

RADIOCARBON DATING SERVICES

Mr. DARDEN G. HOOD
Director

RONALD E. HATFIELD
Laboratory Manager

CHRISTOPHER PATRICK
TERESA A. ZILKO-MILLER
Associate Managers

June 29, 1999

Mr. Jack Meyer
Sonoma State University
Anthropological Studies Center
1801 East Cotati, Building 29
Rohnert Park, CA 94928

Dear Mr. Meyer:

Please find enclosed the radiocarbon dating results for one bone, one sediment and four charcoal samples which were submitted for analyses on May 18. Four of them werer large enough for radiometric counting and two of them were very small and required AMS counting. All analytical steps went normally.

Our calendar calibrations are now calculated back to about 19,000 years using the newest calibration data as published in *Radiocarbon*, Vol. 40, No. 3, 1998 using the cubic spline fit mathematics as published by Talma and Vogel, *Radiocarbon*, Vol. 35, No. 2, pg 317-322, 1993: A Simplified Approach to Calibrating C14 Dates. Results are reported both as cal BC and cal BP. You will notice a slight difference in the layout of the calendar calibration printout. In this new version, we use the same smoothing mathematics as in our previous calibrations, except for dates which are older than about 10,000 BP (land) and 8200 BP (marine). The correlation data is imprecise beyond these points and we use the error limits on a spline fit beyond that range. Since the calibration database may change in the future (especially for the older samples) it is important to quote the original BP dates and the calibration references in your publications.

The calendar calibration printouts are now available via email. If you are using Windows, we can send them to you via Windows metafile. With some email software, this can be opened by clicking on the file. Elswise, you can save the file and then insert it into your word processor as a picture. If you are interested to receive printouts by email, let us know and we'll send them to you.

Two invoices are enclosed as requested. They include charges for one additional sample which is pending AMS analysis (to be reported soon). Please, immediately give them to the appropriate office for prompt payment or send VISA charge authorization. Thank you.

Sincerely,

Darden Hood

4985 S.W. 74 COURT, MIAMI, FL 33155 U.S.A.
TELEPHONE: 305-667-5167 / FAX: 305-663-0964 / INTERNET: beta@radiocarbon.com
WEB SITE: http://www.radiocarbon.com

BETA ANALYTIC INC.

RADIOCARBON DATING SERVICES

Mr. DARDEN G. HOOD
Director

RONALD E. HATFIELD
Laboratory Manager

CHRISTOPHER PATRICK
TERESA A. ZILKO-MILLER
Associate Managers

July 2, 1999

Mr. Jack Meyer
Sonoma State University
Anthropological Studies Center
1801 East Cotati, Building 29
Rohnert Park, CA 94928

Dear Mr. Meyer:

Please find enclosed the radiocarbon dating results for one small charcoal sample (GUAD #2) which was converted from radiometric analysis to AMS analysis on June 21. It provided plenty of carbon for accurate dating and all analytical steps went normally.

The cost of analysis was invoiced June 29 along with previously reported results. As always, if you have any questions, don't hesitate to contact us.

Sincerely,

Darden Hood

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BETA

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DR. MURRY TAMERS
MR. DARDEN HOOD
Co-directors

Mr. Ronald Hatfield
Laboratory Manager

Mr. Christopher Patrick
Ms. Teresa Zilko-Miller
Associate Managers

December 15, 1999

Mr. Jack Meyer
Sonoma State University
Anthropological Studies Center
1801 East Cotati, Building 29
Rohnert Park, CA 94928

Dear Jack:

Please find enclosed the radiocarbon dating result for one charcoal, one shell and seven organic sediment samples (Guad #s 3, 5 through 12) which were received on November 2. They each provided plenty of carbon for accurate radiometric analysis and all analytical steps went normally.

Printouts of the calendar calibrations are enclosed. The two sigma results are as follows;

Beta-135951: Cal AD 1635 to 1895 (Cal BP 315 to 55) and
Cal AD 1930 to 1950 (Cal BP 20 to 0)
Beta-135953: Cal BC 13625 to 12195 (Cal BP 15575 to 14145)
Beta-135954: Cal BC 8765 to 7940 (Cal BP 10715 to 9890)
Beta-135955: Cal BC 1670 to 1040 (Cal BP 3620 to 2990)
Beta-135956: Cal BC 4035 to 3710 (Cal BP 5985 to 5660)
Beta-135957: Cal BC 11905 to 11445 (Cal BP 13855 to 13395) and
Cal BC 11420 to 11370 (Cal BP 13370 to 13320)
Beta-135958: Cal BC 9145 to 8965 (Cal BP 11095 to 10915) and
Cal BC 8945 to 8480 (Cal BP 10895 to 10430)
Beta-135959: Cal BC 8240 to 7630 (Cal BP 10190 to 9580)
Beta-135960: Cal BC 2885 to 2455 (Cal BP 4835 to 4405)

Multiple ranges are possible in some cases due to wiggles in the correlation curve in the relative time periods. On the printouts, you'll notice the calibrations for Beta-135953 and Beta-135957 were calculated using the error limits on the correlation curve points rather than directly on the spline fit. This is to help compensate for the low precision in the calibration curve in this region.

Our invoice is enclosed. Please, forward it to the appropriate office or send VISA charge authorization. Thank you. As always, if you have any questions or would like to discuss the results, don't hesitate to contact me.

Sincerely,
Darden Hood

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DR. MURRY TAMERS
MR. DARDEN HOOD
Co-directors

Mr. Ronald Hatfield
Laboratory Manager

Mr. Christopher Patrick
Ms. Teresa Zilko-Miller
Associate Managers

December 18, 1999

Mr. Jack Meyer
Sonoma State University
Anthropological Studies Center
1801 East Cotati, Building 29
Rohnert Park, CA 94928

Dear Jack:

Please find enclosed the radiocarbon dating result for one small charcoal sample (Guad #4) which was authorized for AMS analysis on December 6. It provided plenty of carbon for accurate analysis and all analytical steps went normally. The two sigma calibrated range is Cal AD 1025 to 1225 (Cal BP 925 to 725. The hard copy print out is enclosed.

The cost of analysis was previously invoiced on September 2. A copy is enclosed. As always, if you have any questions or would like to discuss the results, don't hesitate to contact me.

Sincerely,

Darden Hood

June 9, 2000

Dr. James H. Cleland
KEA Environmental
1420 Kettner Blvd., Ste. 620
San Diego, CA 92101
USA

Dear Dr. Cleland:

Enclosed is the radiocarbon dating result for one sample recently sent to us. It provided plenty of carbon for reliable measurements and the analysis went normally. The report sheet contains the dating result, method used, material type, applied pretreatments and calendar calibration results (where applicable).

This report has been both mailed and sent electronically, along with a graphical representation of a calendar calibration, if appropriate. Calendar calibrations are available as individual Windows metafiles (wmf) upon request. These are useful for incorporating directly into your reports. Calibrations are calculated using the newest (1998) calibration data. References are quoted on the bottom of each calibration page. The upper limit is about 20,000 years for calendar calibration. Multiple probability ranges may appear in some cases, due to short term variations in the atmospheric 14C contents at certain time periods. Examining the calibration graphs will help you understand this phenomenon.

We analyzed this sample on a sole priority basis. No students or intern researchers who would necessarily be distracted with other obligations and priorities were used in the analysis. They were analyzed by our full-time professional staff.

Information pages are also enclosed with the mailed copy of this report. They should answer most of any questions you may have, if they do not, please do not hesitate to contact us for specific discussions. Someone is always available to talk to you.

Our invoice is enclosed. Please, immediately give it to the appropriate office for prompt payment or send VISA charge authorization. Thank you. As always, if you have any questions or would like to discuss the results, don't hesitate to contact me.

Sincerely,

Lethia Cerda

KEA Environmental | Material Received: 5/16/2000

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 143250	1400 +/- 40 BP	-23.5 o/oo	1420 +/- 40 BP

SAMPLE : 807h-1
ANALYSIS : AMS-Advance delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 570 to 670 (Cal BP 1380 to 1280)

Mr. DARDEN G. HOOD
Director

RONALD E. HATFIELD
Laboratory Manager

CHRISTOPHER PATRICK
TERESA A. ZILKO-MILLER
Associate Managers

ANALYTICAL PROCEDURES AND FINAL REPORT

FINAL REPORT

This package includes the final date report, this statement outlining our analytical procedures, a glossary of pretreatment terms, calendar calibration information, billing documents (containing balance/credit information and the number of samples submitted within the yearly discount period), and peripheral items to use with future submittals. The final report includes the individual analysis method, the delivery basis, the material type and the individual pretreatments applied. Please recall any correspondences or communications we may have had regarding sample integrity, size, special considerations or conversions from one analytical technique to another (e.g. radiometric to AMS). The final report has also been sent by fax or e-mail, where available.

PRETREATMENT

Results were obtained on the portion of suitable carbon remaining after any necessary chemical and mechanical pretreatments of the submitted material. Pretreatments were applied, where necessary, to isolate ^{14}C which may best represent the time event of interest. Individual pretreatments are listed on the report next to each result and are defined in the enclosed glossary. When interpreting the results, it is important to consider the pretreatments. Some samples cannot be fully pretreated making their ^{14}C ages more subjective than samples which can be fully pretreated. Some materials receive no pretreatments. Please read the pretreatment glossary.

ANALYSIS

Materials measured by the radiometric technique were analyzed by synthesizing sample carbon to benzene (92% C), measuring for ^{14}C content in a scintillation spectrometer, and then calculating for radiocarbon age. If the Extended Counting Service was used, the ^{14}C content was measured for a greatly extended period of time. AMS results were derived from reduction of sample carbon to graphite (100 %C), along with standards and backgrounds. The graphite was then sent for ^{14}C measurement in an accelerator-mass-spectrometer located at one of six collaborating research facilities, who return the results to us for verification, isotopic fractionation correction, calendar calibration, and reporting.

THE RADIOCARBON AGE AND CALENDAR CALIBRATION

The "Conventional C14 Age (*)" is the result after applying C13/C12 corrections to the measured age and is the most appropriate radiocarbon age (the "*" is discussed at the bottom of the final report). Applicable calendar calibrations are included for organic materials and fresh water carbonates between 0 and 10,000 BP and for marine carbonates between 0 and 8,300 BP. If certain calibrations are not included with this report, the results were either too young, too old, or inappropriate for calibration.

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PRETREATMENT GLOSSARY

Pretreatment of submitted materials is required to eliminate secondary carbon components. These components, if not eliminated, could result in a radiocarbon date which is too young or too old. Pretreatment does not ensure that the radiocarbon date will represent the time event of interest. This is determined by the sample integrity. The old wood effect, burned intrusive roots, bioturbation, secondary deposition, secondary biogenic activity incorporating recent carbon (bacteria) and the analysis of multiple components of differing age are just some examples of potential problems. The pretreatment philosophy is to reduce the sample to a single component, where possible, to minimize the added subjectivity associated with these types of problems.

"acid/alkali/acid"

The sample was first gently crushed/dispersed in deionized water. It was then given hot HCl acid washes to eliminate carbonates and alkali washes (NaOH) to remove secondary organic acids. The alkali washes were followed by a final acid rinse to neutralize the solution prior to drying. Chemical concentrations, temperatures, exposure times, and number of repetitions, were applied accordingly with the uniqueness of the sample. Each chemical solution was neutralized prior to application of the next. During these serial rinses, mechanical contaminants such as associated sediments and rootlets were eliminated. This type of pretreatment is considered a "full pretreatment". On occasion the report will list the pretreatment as "acid/alkali/acid - insolubles" to specify which fraction of the sample was analyzed. This is done on occasion with sediments (See "acid/alkali/acid - solubles"

Typically applied to: charcoal, wood, some peats, some sediments, textiles

"acid/alkali/acid - solubles"

On occasion the alkali soluble fraction will be analyzed. This is a special case where soil conditions imply that the soluble fraction will provide a more accurate date. It is also used on some occasions to verify the present/absence or degree of contamination present from secondary organic acids. The sample was first pretreated with acid to remove any carbonates and to weaken organic bonds. After the alkali washes (as discussed above) are used, the solution containing the alkali soluble fraction is isolated/filtered and combined with acid. The soluble fraction which precipitates is rinsed and dried prior to combustion.

"acid washes"

Surface area was increased as much a possible. Solid chunks were crushed, fibrous materials were shredded, and sediments were dispersed. Acid (HCl) was applied repeatedly to ensure the absence of carbonates. Chemical concentrations, temperatures, exposure times, and number of repetitions, were applied accordingly with the uniqueness of each sample. The sample, for a number of reasons, could not be subjected to alkali washes to ensure the absence of secondary organic acids. The most common reason is that the primary carbon is soluble in the alkali. Dating results reflect the total organic content of the analyzed material. Their accuracy depends on the researcher's ability to subjectively eliminate potential contaminants based on contextual facts.

Typically applied to: organic sediments, some peats, small wood or charcoal, special cases

'collagen extraction"

The material was first tested for friability ("softness"). Very soft bone material is an indication of the potential absence of the collagen fraction (basal bone protein acting as a "reinforcing agent" within the crystalline apatite structure). It was then washed in de-ionized water and gently crushed. Dilute, cold HCl acid was repeatedly applied and replenished until the mineral fraction (bone apatite) was eliminated. The collagen was then dissected and inspected for rootlets. Any rootlets present were also removed when replenishing the acid solutions. Where possible, usually dependant on the amount of collagen available, alkali (NaOH) was also applied to ensure the absence of secondary organic acids.

Typically applied to: bones

"acid etch"

The calcareous material was first washed in de-ionized water, removing associated organic sediments and debris (where present). The material was then crushed/dispersed and repeatedly subjected to HCl etches to eliminate secondary carbonate components. In the case of thick shells, the surfaces were physically abraded prior to etching down to a hard, primary core remained. In the case of porous carbonate nodules and caliche, very long exposure times were applied to allow infiltration of the acid. Acid exposure times, concentrations, and number of repetitions, were applied accordingly with the uniqueness of the sample.

Typically applied to: shells, caliche, calcareous nodules

"neutralized"

Carbonates precipitated from ground water are usually submitted in an alkaline condition (ammonium hydroxide or sodium hydroxide solution). Typically this solution is neutralized in the original sample container, using deionized water. If larger volume dilution was required, the precipitate and solution were transferred to a sealed separatory flask and rinsed to neutrality. Exposure to atmosphere was minimal.

Typically applied to: Strontium carbonate, Barium carbonate
(i.e. precipitated ground water samples)

"none"

No laboratory pretreatments were applied. Special requests and pre-laboratory pretreatment usually accounts for this.

"acid/alkali/acid/cellulose extraction"

Following full acid/alkali/acid pretreatments, the sample is rinsed in NaClO2 under very controlled conditions (Ph = 3, temperature = 70 degrees C). This eliminates all components except wood cellulose. It is useful for woods which are either very old or highly contaminated.

Applied to: wood

"carbonate precipitation"

Dissolved carbon dioxide and carbonate species are precipitated from submitted water by complexing them as amonium carbonate. Strontium chloride is added to the ammonium carbonate solution and strontium carbonate is precipitated for the analysis. The result is representative of the dissolved inorganic carbon within the water. Results are reported as "water DIC".

Applied to: water

BETA ANALYTIC INC.
RADIOCARBON DATING LABORATORY
CALIBRATED C-14 DATING RESULTS

Calibrations of radiocarbon age determinations are applied to convert BP results to calendar years. The short term difference between the two is caused by fluctuations in the heliomagnetic modulation of the galactic cosmic radiation and, recently, large scale burning of fossil fuels and nuclear devices testing. Geomagnetic variations are the probable cause of longer term differences.

The parameters used for the corrections have been obtained through precise analyses of hundreds of samples taken from known-age tree rings of oak, sequoia, and fir up to about 10,000 BP. Calibration using tree-rings to about 12,000 BP is still being researched and provides somewhat less precise correlation. Beyond that, up to about 20,000 BP, correlation using a modeled curve determined from U/Th measurements on corals is used. This data is still highly subjective. Calibrations are provided up to about 19,000 years BP using the most recent calibration data available (Radiocarbon, Vol 40, No. 3, 1998).

The Pretoria Calibration Procedure (Radiocarbon, Vol 35, No. 1, 1993, pg 317) program has been chosen for these calendar calibrations. It uses splines through the tree-ring data as calibration curves, which eliminates a large part of the statistical scatter of the actual data points. The spline calibration allows adjustment of the average curve by a quantified closeness-of-fit parameter to the measured data points. A single spline is used for the precise correlation data available back to 9900 BP for terrestrial samples and about 6900 BP for marine samples. Beyond that, splines are taken on the error limits of the correlation curve to account for the lack of precision in the data points.

In describing our calibration curves, the solid bars represent one sigma statistics (68% probability) and the hollow bars represent two sigma statistics (95% probability). Marine carbonate samples that have been corrected for δ 13/12C, have also been corrected for both global and local geographic reservoir effects (as published in Radiocarbon, Volume 35, Number 1, 1993) prior to the calibration. Marine carbonates that have not been corrected for δ 13/12C are adjusted by an assumed value of 0 ‰ in addition to the reservoir corrections. Reservoir corrections for fresh water carbonates are usually unknown and are generally not accounted for in those calibrations. In the absence of measured δ 13/12C ratios, a typical value of -5 ‰ is assumed for freshwater carbonates.

(Caveat: the correlation curve for organic materials assume that the material dated was living for exactly ten years (e.g. a collection of 10 individual tree rings taken from the outer portion of a tree that was cut down to produce the sample in the feature dated). For other materials, the maximum and minimum calibrated age ranges given by the computer program are uncertain. The possibility of an "old wood effect" must also be considered, as well as the potential inclusion of younger or older material in matrix samples. Since these factors are indeterminant error in most cases, these calendar calibration results should be used only for illustrative purposes. In the case of carbonates, reservoir correction is theoretical and the local variations are real, highly variable and dependant on provenience. Since imprecision in the correlation data beyond 10,00 years is high, calibrations in this range are likely to change in the future with refinement in the correlation curve. The age ranges and especially the intercept ages generated by the program, must be considered as approximations.)

BETA

BETA ANALYTIC INC.

DR. M.A. TAMERS and MR. D.G. HOOD

UNIVERSITY BRANCH
4985 S.W. 74 COURT
MIAMI, FLORIDA, USA 33155
PH: 305/667-5167 FAX: 305/663-0964
E-MAIL: beta@radiocarbon.com

REPORT OF RADIOCARBON DATING ANALYSES

Mr. Jack Meyer

May 18, 1999

Sonoma State University

June 29, 1999

Sample Data	Measured C14 Age	C13/C12 Ratio	Conventional C14 Age (*)
Beta-130741	6320 +/- 70 BP	-25.4 o/oo	6320 +/- 70 BP

SAMPLE #: GUAD#1
ANALYSIS: radiometric-standard
MATERIAL/PRETREATMENT:(organic sediment): acid washes
COMMENT: low carbon sediment requiring special handling

[redacted]	[redacted]	[redacted]	[redacted]

SAMPLE #: [redacted]
ANALYSIS: radiometric-standard
MATERIAL/PRETREATMENT:(charred material): acid/alkali/acid

[redacted]	[redacted]	[redacted]	[redacted]

SAMPLE #: [redacted]
ANALYSIS: Standard-AMS
MATERIAL/PRETREATMENT:(charred material): acid/alkali/acid

[redacted]	[redacted]	[redacted]	[redacted]

SAMPLE #: [redacted]
ANALYSIS: radiometric-standard
MATERIAL/PRETREATMENT:(charred material): acid/alkali/acid

[redacted]	[redacted]	[redacted]	[redacted]

SAMPLE #: [redacted]
ANALYSIS: radiometric-standard
MATERIAL/PRETREATMENT:(bone collagen): collagen extraction (acid only)

Dates are reported as RCYBP (radiocarbon years before present, "present" = 1950A.D.). By International convention, the modern reference standard was 95% of the C14 content of the National Bureau of Standards' Oxalic Acid & calculated using the Libby C14 half life (5568 years). Quoted errors represent 1 standard deviation statistics (68% probability) & are based on combined measurements of the sample, background, and modern reference standards.

Measured C13/C12 ratios were calculated relative to the PDB-1 international standard and the RCYBP ages were normalized to -25 per mil. If the ratio and age are accompanied by an (*), then the C13/C12 value was estimated, based on values typical of the material type. The quoted results are NOT calibrated to calendar years. Calibration to calendar years should be calculated using the Conventional C14 age.

BETA

BETA ANALYTIC INC.

DR. M.A. TAMERS and MR. D.G. HOOD

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REPORT OF RADIOCARBON DATING ANALYSES

Mr. Jack Meyer

Sonoma State University

Auth. June 21, 1999

July 2, 1999

Sample Data	Measured C14 Age	C13/C12 Ratio	Conventional C14 Age (*)
Beta-130742	6710 +/- 40 BP	-25.7 o/oo	6700 +/- 40 BP

SAMPLE #: GUAD #2
ANALYSIS: Standard-AMS
MATERIAL/PRETREATMENT:(charred material): acid/alkali/acid

NOTE: It is important to read the calendar calibration information and to use the calendar calibrated results (reported separately) when interpreting these results in AD/BC terms.

Dates are reported as RCYBP (radiocarbon years before present, "present" = 1950A.D.). By International convention, the modern reference standard was 95% of the C14 content of the National Bureau of Standards' Oxalic Acid & calculated using the Libby C14 half life (5568 years). Quoted errors represent 1 standard deviation statistics (68% probability) & are based on combined measurements of the sample, background, and modern reference standards.

Measured C13/C12 ratios were calculated relative to the PDB-1 international standard and the RCYBP ages were normalized to -25 per mil. If the ratio and age are accompanied by an (*), then the C13/C12 value was estimated, based on values typical of the material type. The quoted results are NOT calibrated to calendar years. Calibration to calendar years should be calculated using the Conventional C14 age.

BETA

BETA ANALYTIC INC.

DR. M.A. TAMERS and MR. D.G. HOOD

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REPORT OF RADIOCARBON DATING ANALYSES

Mr. Jack Meyer

Sonoma State University

Report Date: December 15, 1999

Material Received: November 2, 1999

Sample Data	Measured Radiocarbon Age	$^{13}C/^{12}C$ Ratio	Conventional Radiocarbon Age (*)
Beta-135951	200 +/- 60 BP	- 1.6 o/oo	580 +/- 60 BP
SAMPLE #: Guad #3 ANALYSIS: radiometric-standard MATERIAL/PRETREATMENT:(shell): acid etch			
Beta-135953	12500 +/- 110 BP	-22.8 o/oo	12540 +/- 110 BP
SAMPLE #: Guad #5 ANALYSIS: radiometric-standard MATERIAL/PRETREATMENT:(organic sediment): acid washes COMMENT: low carbon sediment requiring special handling			
Beta-135954	9130 +/- 170 BP	-23.8 o/oo	9150 +/- 170 BP
SAMPLE #: Guad #6 ANALYSIS: radiometric-standard MATERIAL/PRETREATMENT:(organic sediment): acid washes COMMENT: low carbon sediment requiring special handling			
Beta-135955	3120 +/- 120 BP	-24.8 o/oo	3130 +/- 120 BP
SAMPLE #: Guad #7 ANALYSIS: radiometric-standard MATERIAL/PRETREATMENT:(charred material): acid/alkali/acid COMMENT: the sample was given extended counting time			
Beta-135956	5080 +/- 70 BP	-23.5 o/oo	5100 +/- 70 BP
SAMPLE #: Guad #8 ANALYSIS: radiometric-standard MATERIAL/PRETREATMENT:(organic sediment): acid washes COMMENT: low carbon sediment requiring special handling			

Dates are reported as RCYBP (radiocarbon years before present, "present" = 1950A.D.). By international convention, the modern reference standard was 95% of the C14 content of the National Bureau of Standards' Oxalic Acid & calculated using the Libby C14 half life (5568 years). Quoted errors represent 1 standard deviation statistics (68% probability) & are based on combined measurements of the sample, background, and modern reference standards.

Measured C13/C12 ratios were calculated relative to the PDB-1 international standard and the RCYBP ages were normalized to -25 per mil. If the ratio and age are accompanied by an (*), then the C13/C12 value was estimated, based on values typical of the material type. The quoted results are NOT calibrated to calendar years. Calibration to calendar years should be calculated using the Conventional C14 age.

BETA

BETA ANALYTIC INC.

DR. M.A. TAMERS and MR. D.G. HOOD

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REPORT OF RADIOCARBON DATING ANALYSES

Mr. Jack Meyer

Sample Data	Measured Radiocarbon Age	$^{13}C/^{12}C$ Ratio	Conventional Radiocarbon Age (*)
Beta-135957 SAMPLE #: Guad #9 ANALYSIS: radiometric-standard MATERIAL/PRETREATMENT:(organic sediment): acid washes COMMENT: low carbon sediment requiring special handling	11600 +/- 80 BP	-23.5 o/oo	11620 +/- 80 BP
Beta-135958 SAMPLE #: Guad #10 ANALYSIS: radiometric-standard MATERIAL/PRETREATMENT:(organic sediment): acid washes COMMENT: low carbon sediment requiring special handling	9430 +/- 90 BP	-24.6 o/oo	9440 +/- 90 BP
Beta-135959 SAMPLE #: Guad #11 ANALYSIS: radiometric-standard MATERIAL/PRETREATMENT:(organic sediment): acid washes COMMENT: low carbon sediment requiring special handling	8830 +/- 80 BP	-24.0 o/oo	8840 +/- 80 BP
Beta-135960 SAMPLE #: Guad #12 ANALYSIS: radiometric-standard MATERIAL/PRETREATMENT:(organic sediment): acid washes COMMENT: low carbon sediment requiring special handling	4090 +/- 80 BP	-25.7 o/oo	4080 +/- 80 BP

NOTE: It is important to read the calendar calibration information and to use the calendar calibrated results (reported separately) when interpreting these results in AD/BC terms.
NOTE: Sample"Guad #4" is currently being analyzed and will be reported separately.

Dates are reported as RCYBP (radiocarbon years before present, "present" = 1950A.D.). By International convention, the modern reference standard was 95% of the C14 content of the National Bureau of Standards' Oxalic Acid & calculated using the Libby C14 half life (5568 years). Quoted errors represent 1 standard deviation statistics (68% probability) & are based on combined measurements of the sample, background, and modern reference standards.

Measured C13/C12 ratios were calculated relative to the PDB-1 international standard and the RCYBP ages were normalized to -25 per mil. If the ratio and age are accompanied by an (*), then the C13/C12 value was estimated, based on values typical of the material type. The quoted results are NOT calibrated to calendar years. Calibration to calendar years should be calculated using the Conventional C14 age.

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BETA ANALYTIC INC.

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REPORT OF RADIOCARBON DATING ANALYSES

Mr. Jack Meyer

Sonoma State University

Report Date: December 18, 1999

Material Received: Auth. Dec. 6, 1999

Sample Data	Measured Radiocarbon Age	^{13}C / ^{12}C Ratio	Conventional Radiocarbon Age (*)
Beta-135952	920 +/- 40 BP	-26.3 o/oo	900 +/- 40 BP

SAMPLE #: Guad #4
ANALYSIS: Standard-AMS
MATERIAL/PRETREATMENT:(charred material): acid/alkali/acid

NOTE: It is important to read the calendar calibration information and to use the calendar calibrated results (reported separately) when interpreting these results in AD/BC terms.

Dates are reported as RCYBP (radiocarbon years before present, "present" = 1950A.D.). By international convention, the modern reference standard was 95% of the C14 content of the National Bureau of Standards' Oxalic Acid & calculated using the Libby C14 half life (5568 years). Quoted errors represent 1 standard deviation statistics (68% probability) & are based on combined measurements of the sample, background, and modern reference standards.

Measured C13/C12 ratios were calculated relative to the PDB-1 international standard and the RCYBP ages were normalized to -25 per mil. If the ratio and age are accompanied by an (*), then the C13/C12 value was estimated, based on values typical of the material type. The quoted results are NOT calibrated to calendar years. Calibration to calendar years should be calculated using the Conventional C14 age.

EXPLANATION OF THE BETA ANALYTIC DENDRO-CALIBRATION PRINTOUT

CALIBRATION OF RADICARBON AGE TO CALENDAR YEARS

ariables used in
e calculation of →
ge calibration

(Variables: C13/C12= :Delta-R= :Glob res= :lab. multi=1)

Laboratory Number: Beta-12345

Conventional radiocarbon age: 2400 +/- 60 BP

The uncalibrated conventional radiocarbon age (± 1 sigma)

ne recommended
alibration age
nge to be used →
r interpretation

Calibrated result: cal BC 770 to 380
(2 sigma, 95% probability)

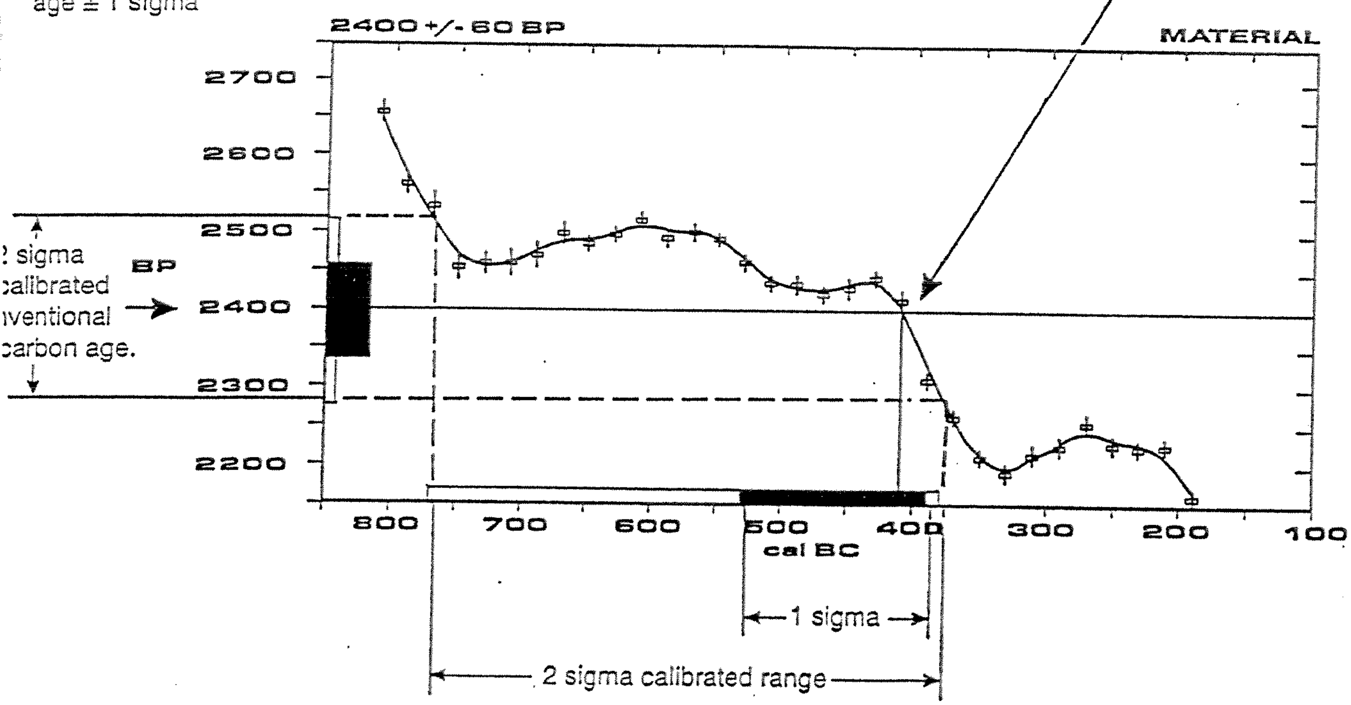
Intercept data:

Intercept of conventional radiocarbon age with calibration curve: cal BC 410

The intercept between the conventional radiocarbon age and the calibrated calendar time scale curve.

The calibration result of the conventional radiocarbon age ± 1 sigma

1 sigma calibrated result: cal BC 530 to 390
(68% probability)



References:

Pretoria Calibration Curve for Short Lived Samples
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Calibration - 1993
Stuiver, M., Long, A., Kra, R.S. and Devine, J.M., 1993, Radiocarbon 35(I)

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porting results (recommended):
List the conventional radiocarbon age with its associated 1 sigma standard deviation in a table and designate it as such.
Discussion of ages in the text should focus on the 2 sigma calibrated range.

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-25.4:lab. mult=1)

Laboratory number: Beta-130741

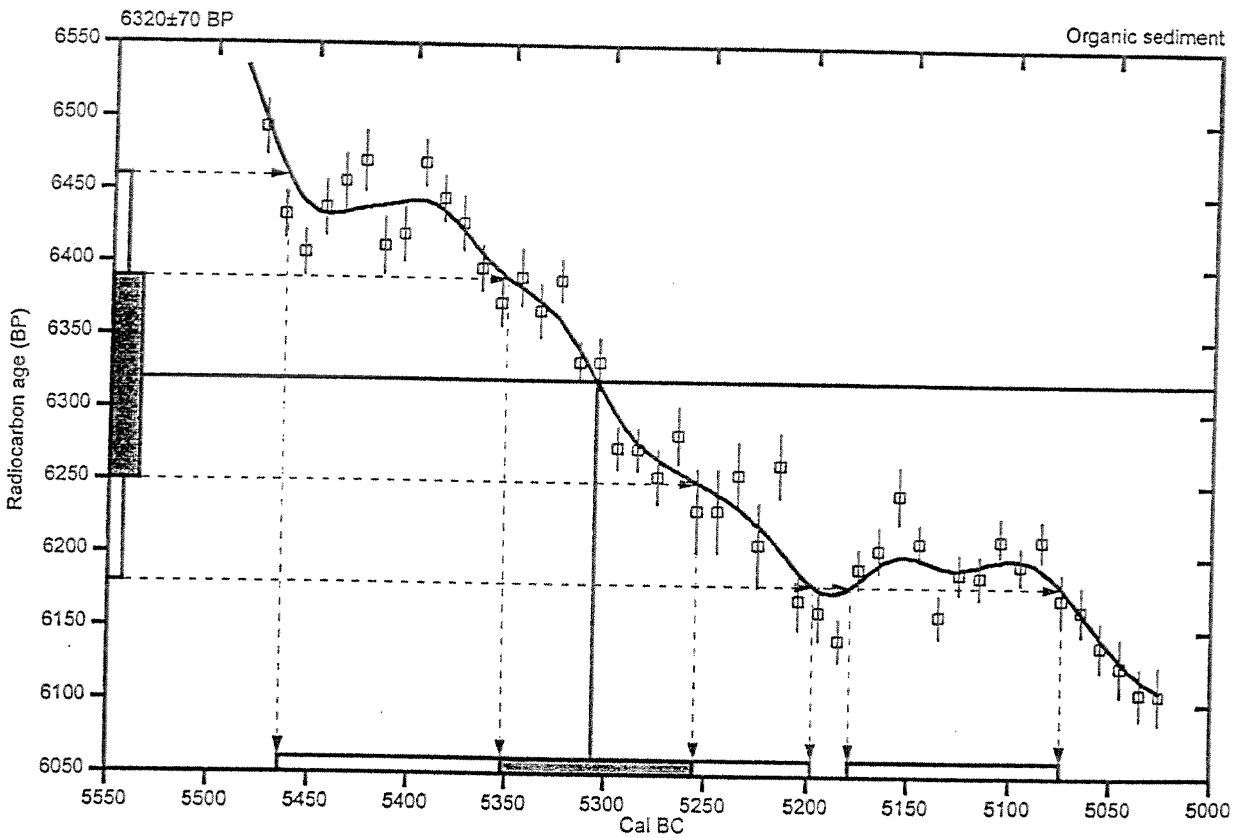
Conventional radiocarbon age: 6320±70 BP

2 Sigma calibrated results: (95% probability) Cal BC 5465 to 5200 (Cal BP 7415 to 7150) and Cal BC 5180 to 5075 (Cal BP 7130 to 7025)

Intercept data

Intercept of radiocarbon age with calibration curve: Cal BC 5305 (Cal BP 7255)

1 Sigma calibrated results: (68% probability) Cal BC 5350 to 5255 (Cal BP 7300 to 7205)



References:

Database used

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-25.7:lab. mult=1)

Laboratory number: Beta-130742

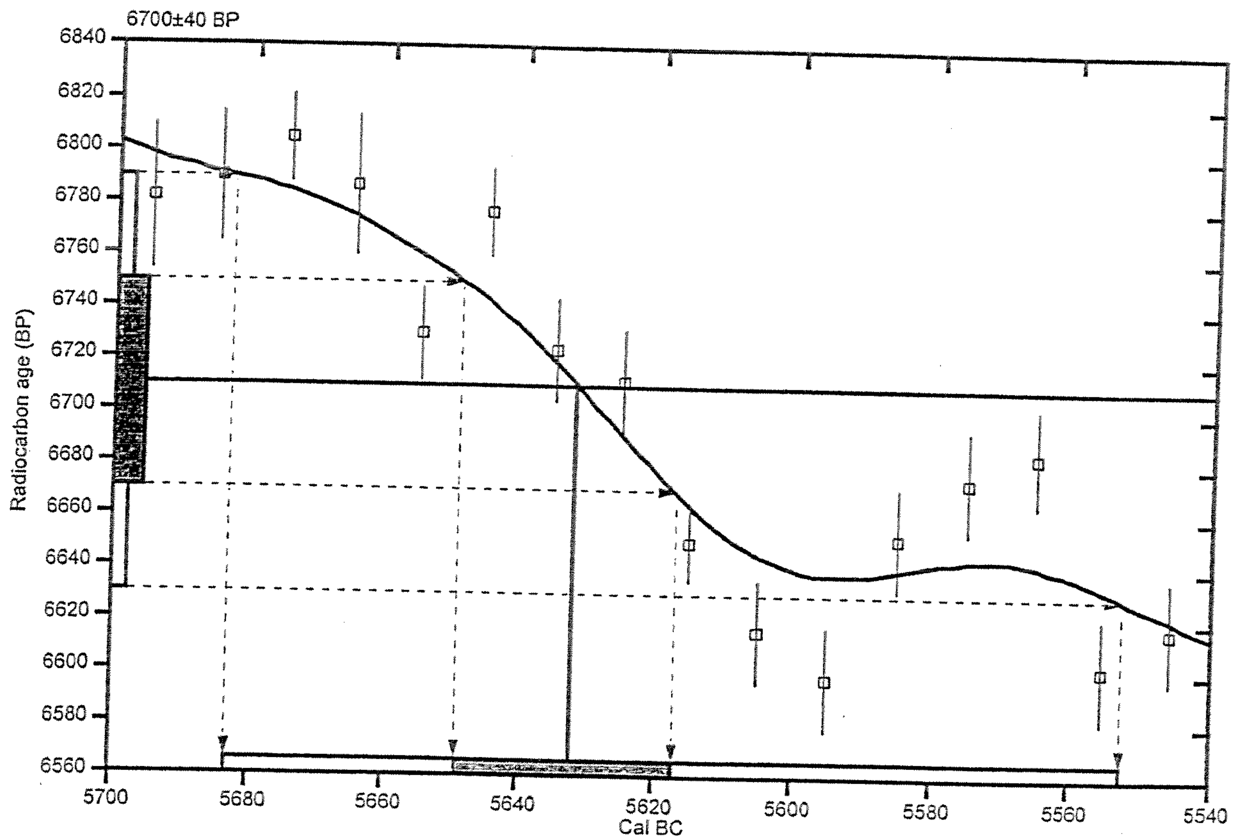
Conventional radiocarbon age: 6700±40 BP

2 Sigma calibrated result: (95% probability) Cal BC 5685 to 5550 (Cal BP 7635 to 7500)

Intercept data

Intercept of radiocarbon age with calibration curve: Cal BC 5630 (Cal BP 7580)

1 Sigma calibrated result: (68% probability) Cal BC 5650 to 5615 (Cal BP 7600 to 7565)



References:

Database used

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INTCAL98 Radiocarbon Age Calibration

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-1.6:Delta-R=0±0:Glob res=-200 to 500:lab. mult=1)

Laboratory number: Beta-135951

Conventional radiocarbon age: 580±60 BP

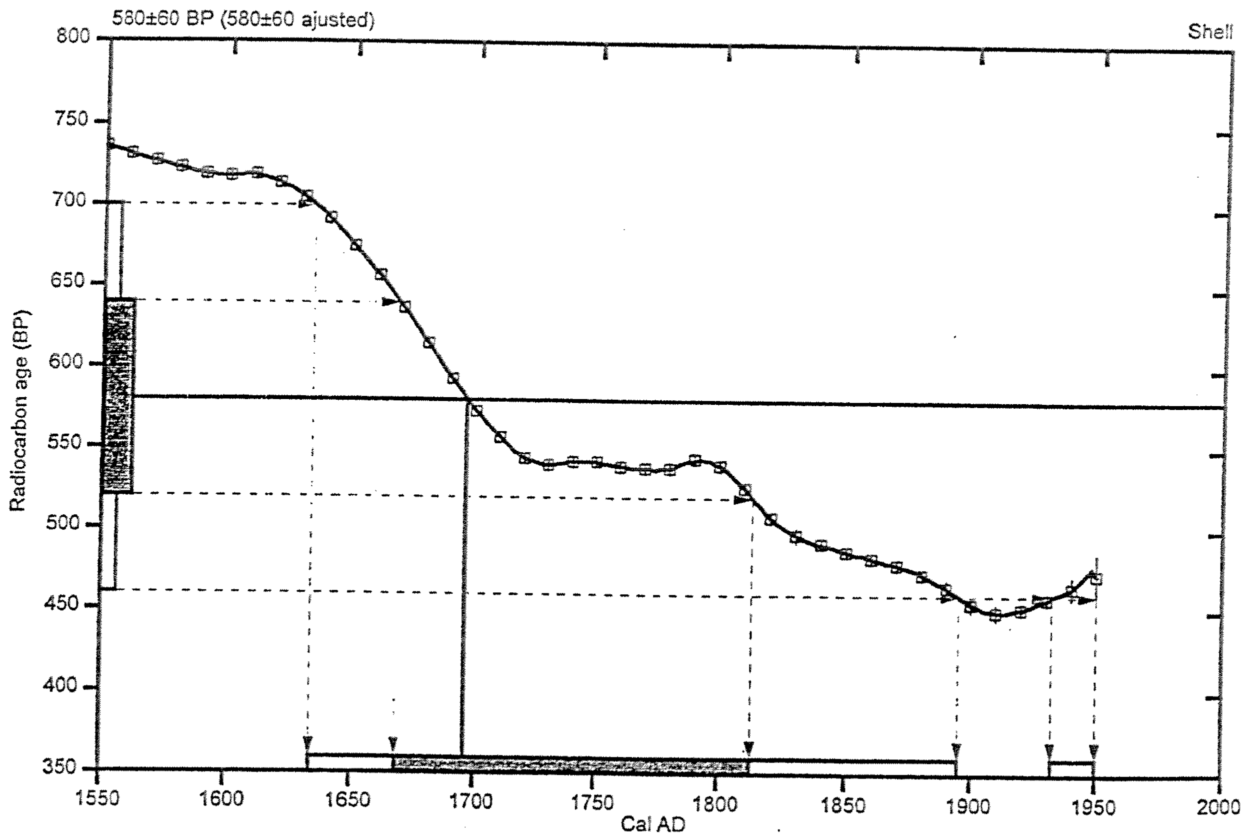
(local reservoir correction not applied)

2 Sigma calibrated results: Cal AD 1635 to 1895 (Cal BP 315 to 55) and
(95% probability) Cal AD 1930 to 1950 (Cal BP 20 to 0)

Intercept data

Intercept of radiocarbon age
with calibration curve: Cal AD 1695 (Cal BP 255)

1 Sigma calibrated result: Cal AD 1670 to 1815 (Cal BP 280 to 135)
(68% probability)



References:

Database used

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-26.3:lab. mult=1)

Laboratory number: Beta-135952

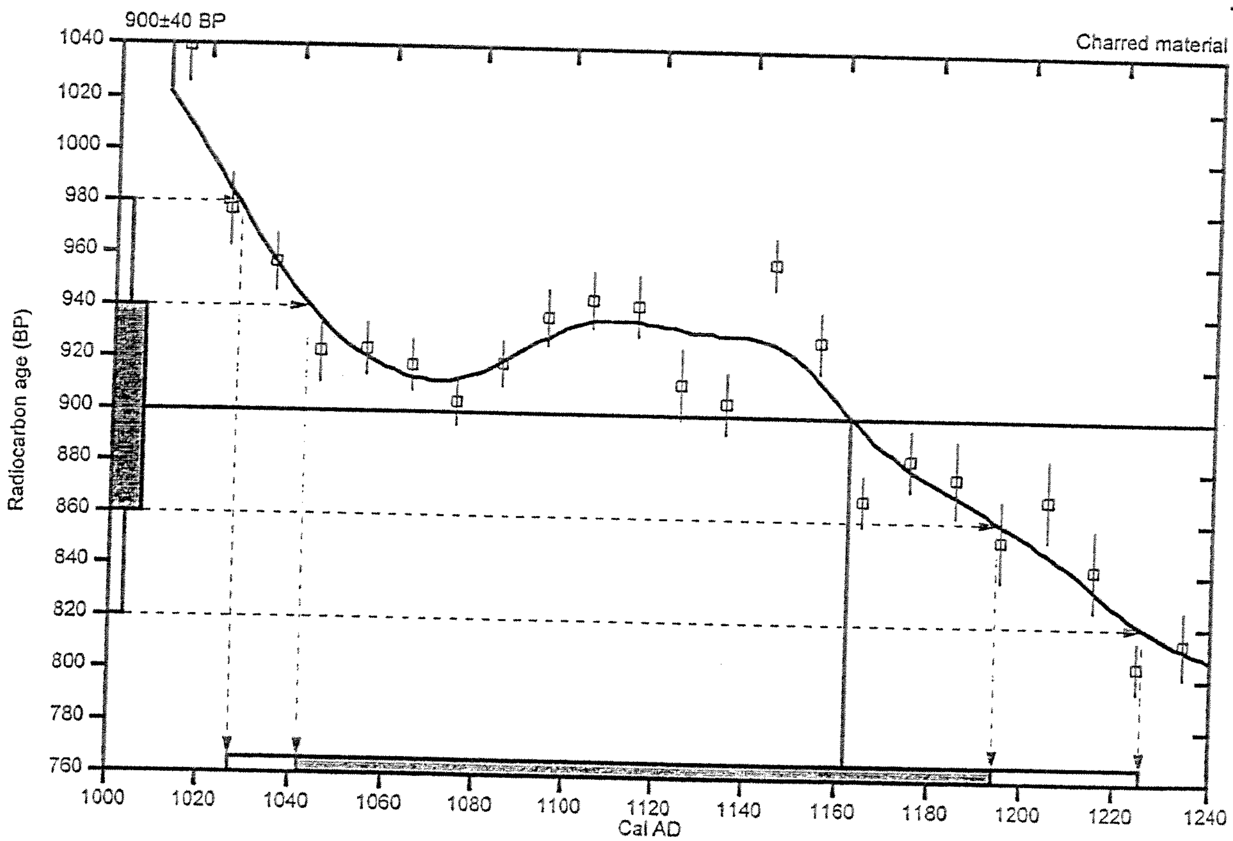
Conventional radiocarbon age: 900±40 BP

2 Sigma calibrated result: (95% probability) Cal AD 1025 to 1225 (Cal BP 925 to 725)

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 1160 (Cal BP 790)

1 Sigma calibrated result: (68% probability) Cal AD 1040 to 1195 (Cal BP 910 to 755)



References:

Database used

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Calibration Database

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-22.8:lab. mult=1)

Laboratory number: **Beta-135953**

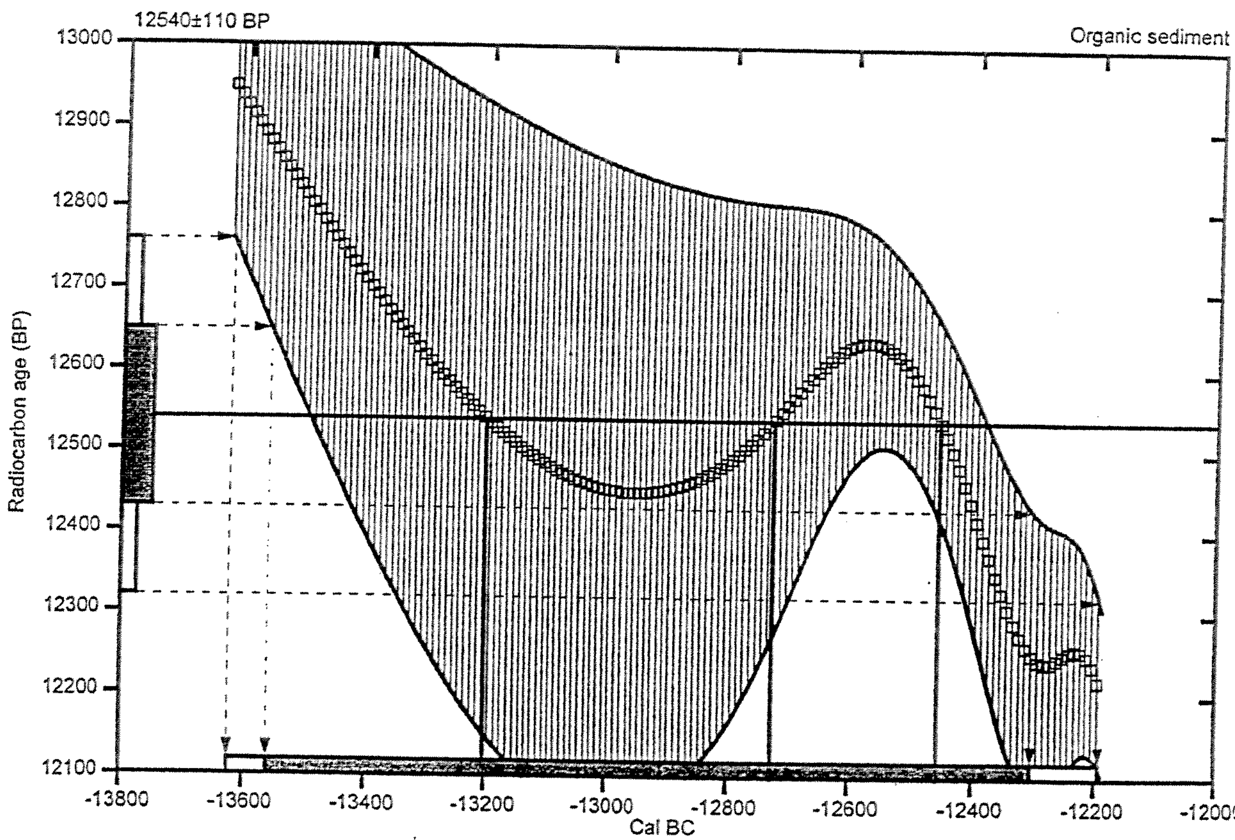
Conventional radiocarbon age: **12540±110 BP**

2 Sigma calibrated result: (95% probability) **Cal BC 13625 to 12195 (Cal BP 15575 to 14145)**

Intercept data

Intercepts of radiocarbon age with calibration curve: Cal BC 13200 (Cal BP 15150) and
Cal BC 12730 (Cal BP 14680) and
Cal BC 12455 (Cal BP 14405)

1 Sigma calibrated result: (68% probability) Cal BC 13560 to 12305 (Cal BP 15510 to 14255)



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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-23.8:lab. mult=1)

Laboratory number: **Beta-135954**

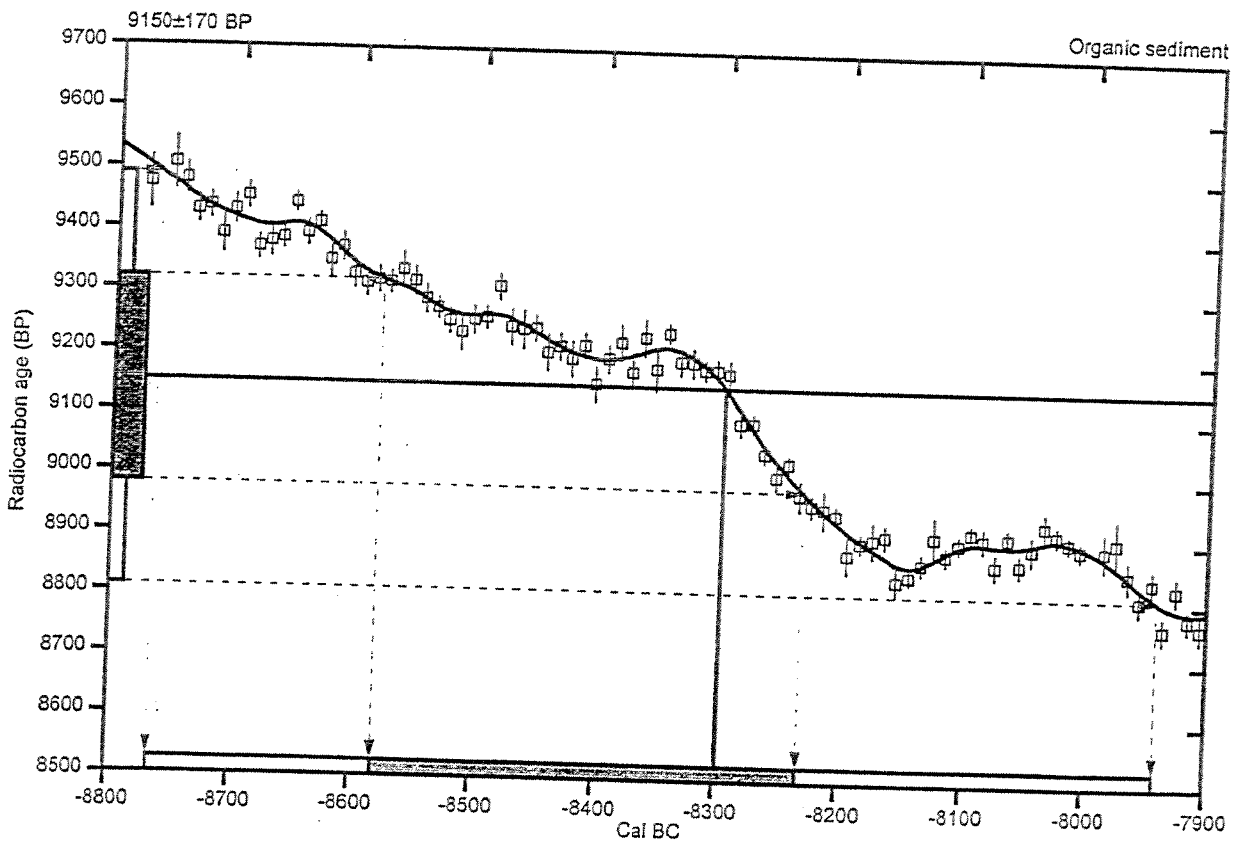
Conventional radiocarbon age: **9150±170 BP**

2 Sigma calibrated result: (95% probability) **Cal BC 8765 to 7940 (Cal BP 10715 to 9890)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal BC 8300 (Cal BP 10250)

1 Sigma calibrated result: (68% probability) Cal BC 8580 to 8230 (Cal BP 10530 to 10180)



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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-24.8:lab. mult=1)

Laboratory number: Beta-135955

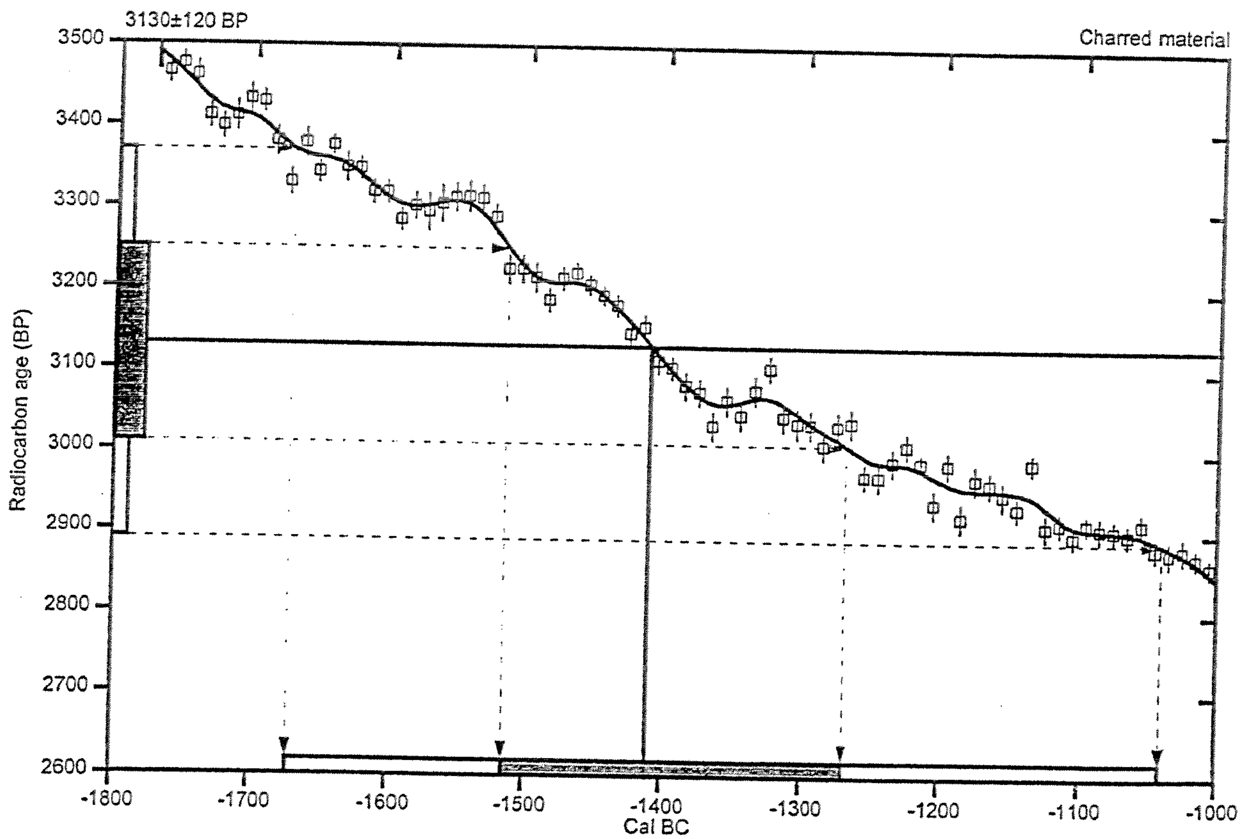
Conventional radiocarbon age: 3130±120 BP

2 Sigma calibrated result: Cal BC 1670 to 1040 (Cal BP 3620 to 2990)
(95% probability)

Intercept data

Intercept of radiocarbon age with calibration curve: Cal BC 1410 (Cal BP 3360)

1 Sigma calibrated result: Cal BC 1515 to 1270 (Cal BP 3465 to 3220)
(68% probability)



References:

Database used

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-23.5:lab. mult=1)

Laboratory number: Beta-135956

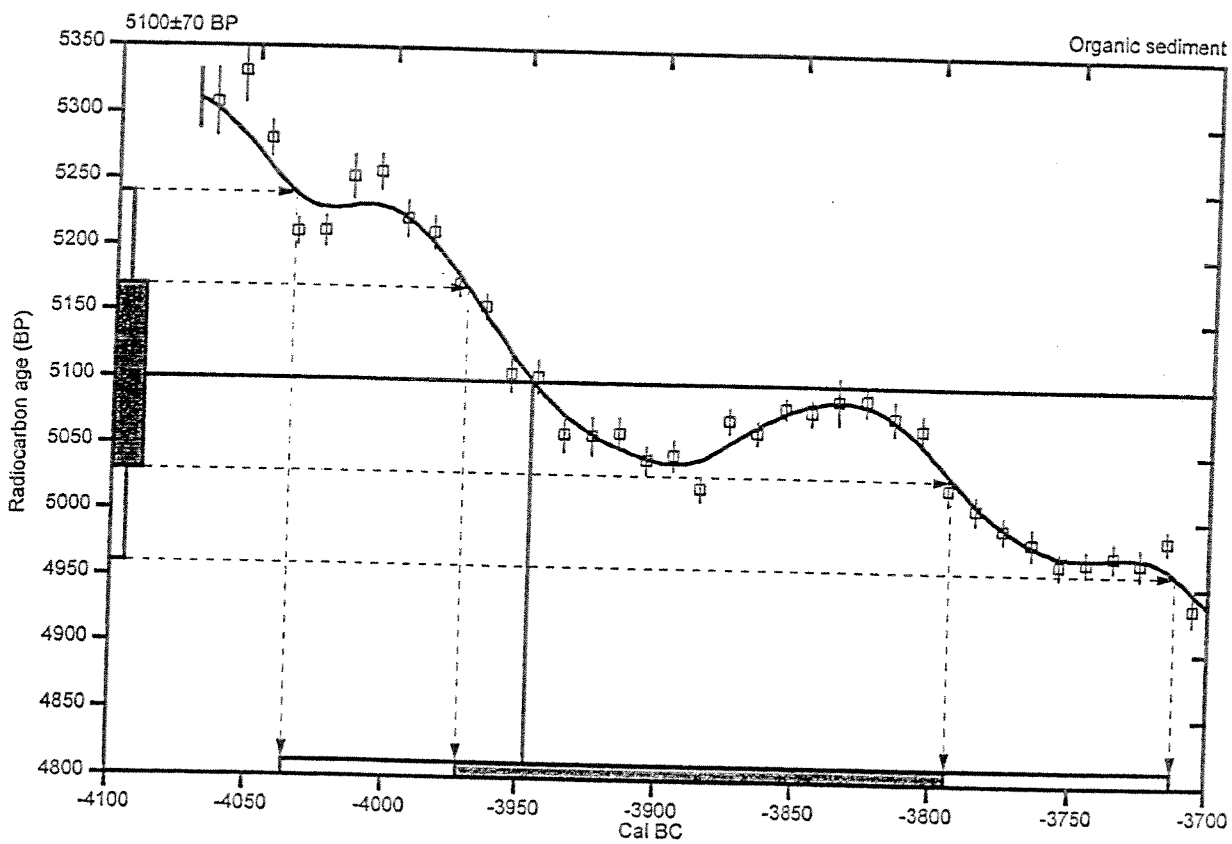
Conventional radiocarbon age: 5100±70 BP

2 Sigma calibrated result: (95% probability) Cal BC 4035 to 3710 (Cal BP 5985 to 5660)

Intercept data

Intercept of radiocarbon age with calibration curve: Cal BC 3945 (Cal BP 5895)

1 Sigma calibrated result: (68% probability) Cal BC 3970 to 3795 (Cal BP 5920 to 5745)



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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-23.5:lab. mult=1)

Laboratory number: Beta-135957

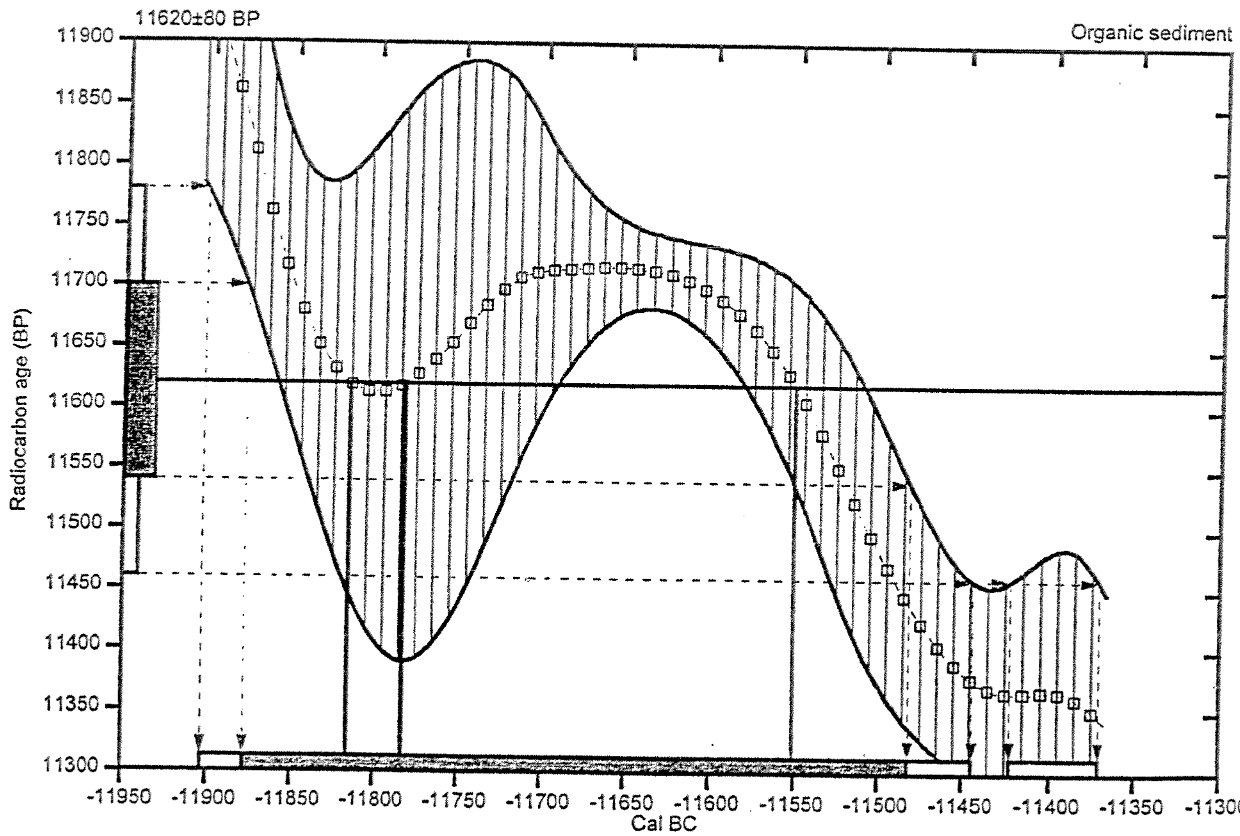
Conventional radiocarbon age: 11620±80 BP

2 Sigma calibrated results: Cal BC 11905 to 11445 (Cal BP 13855 to 13395) and
(95% probability) Cal BC 11420 to 11370 (Cal BP 13370 to 13320)

Intercept data

Intercepts of radiocarbon age with calibration curve: Cal BC 11815 (Cal BP 13765) and
Cal BC 11785 (Cal BP 13735) and
Cal BC 11550 (Cal BP 13500)

1 Sigma calibrated result: Cal BC 11880 to 11480 (Cal BP 13830 to 13430)
(68% probability)



References:

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-24.6:lab. mult=1)

Laboratory number: Beta-135958

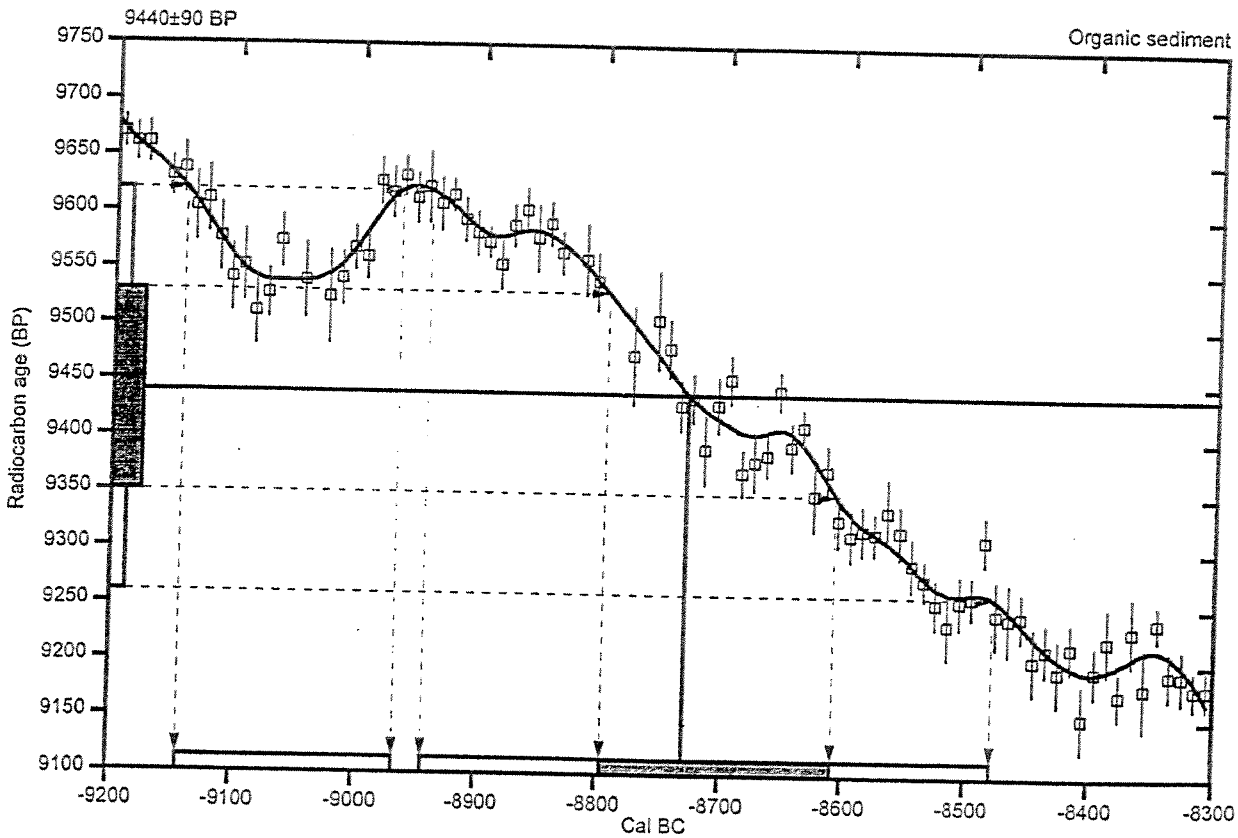
Conventional radiocarbon age: 9440±90 BP

2 Sigma calibrated results: Cal BC 9145 to 8965 (Cal BP 11095 to 10915) and
(95% probability) Cal BC 8945 to 8480 (Cal BP 10895 to 10430)

Intercept data

Intercept of radiocarbon age
with calibration curve: Cal BC 8730 (Cal BP 10680)

1 Sigma calibrated result: Cal BC 8795 to 8610 (Cal BP 10745 to 10560)
(68% probability)



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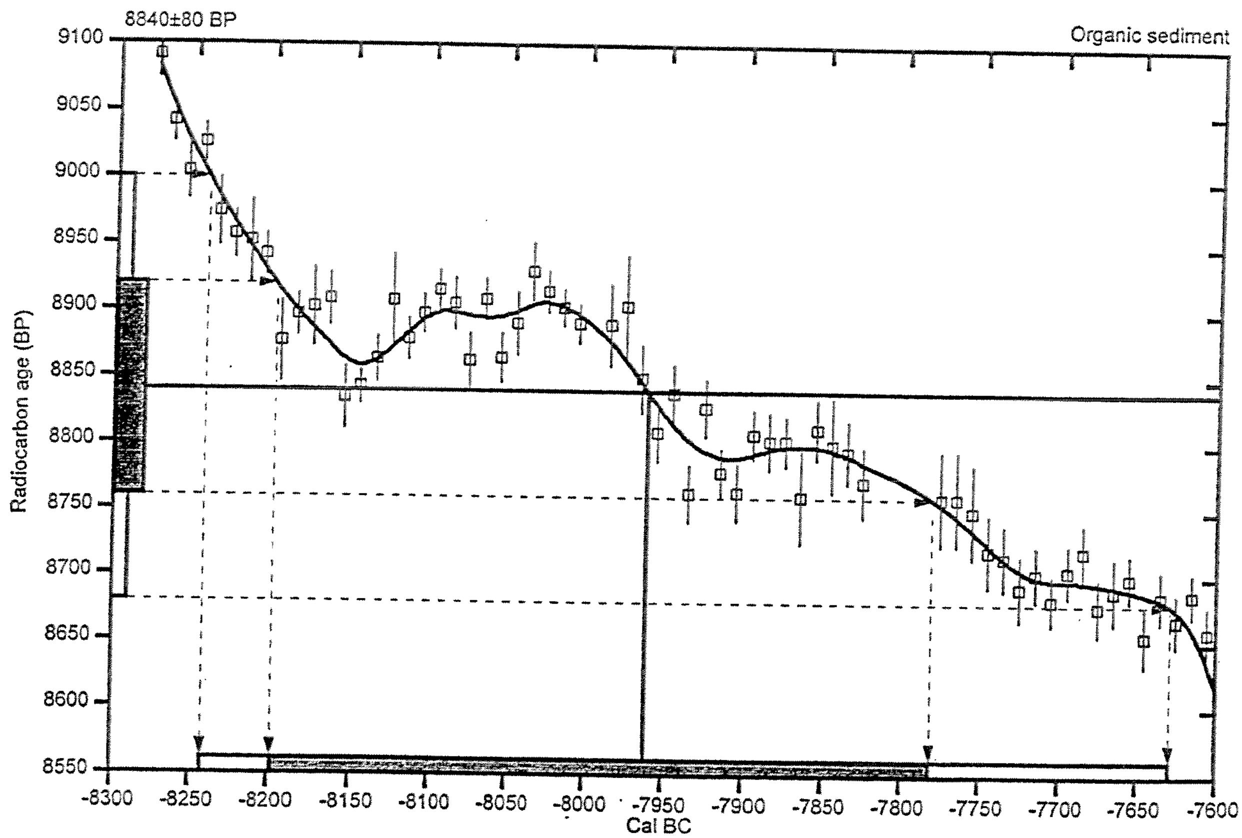
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-24:lab. mult=1)

Laboratory number:	Beta-135959
Conventional radiocarbon age:	8840±80 BP
2 Sigma calibrated result: (95% probability)	Cal BC 8240 to 7630 (Cal BP 10190 to 9580)

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal BC 7960 (Cal BP 9910)
1 Sigma calibrated result: (68% probability)	Cal BC 8200 to 7780 (Cal BP 10150 to 9730)



References:

Database used

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-25.7:lab. mult=1)

Laboratory number: Beta-135960

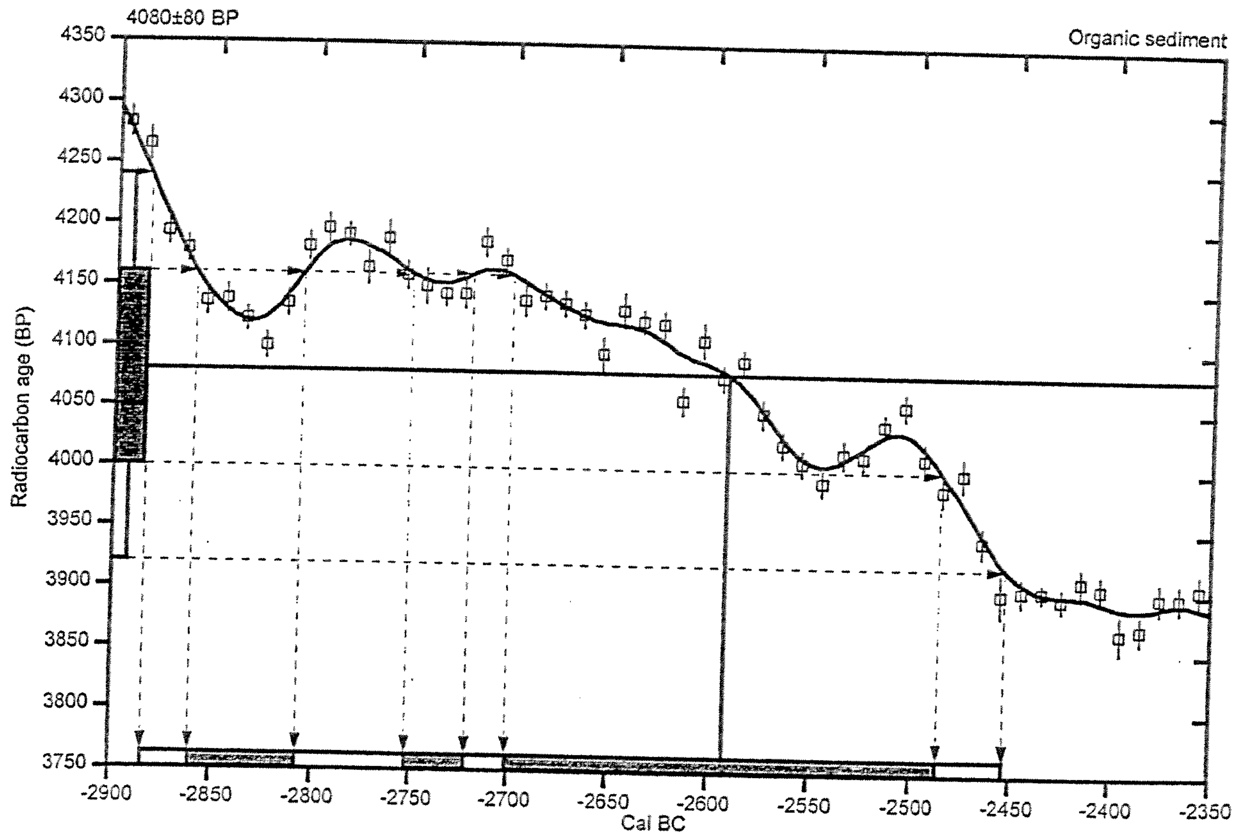
Conventional radiocarbon age: 4080±80 BP

2 Sigma calibrated result: Cal BC 2885 to 2455 (Cal BP 4835 to 4405)
(95% probability)

Intercept data

Intercept of radiocarbon age with calibration curve: Cal BC 2590 (Cal BP 4540)

1 Sigma calibrated results: Cal BC 2860 to 2805 (Cal BP 4810 to 4755) and
(68% probability) Cal BC 2750 to 2720 (Cal BP 4700 to 4670) and
Cal BC 2700 to 2485 (Cal BP 4650 to 4435)



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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-23.5:lab. mult=1)

Laboratory number: **Beta-143250**

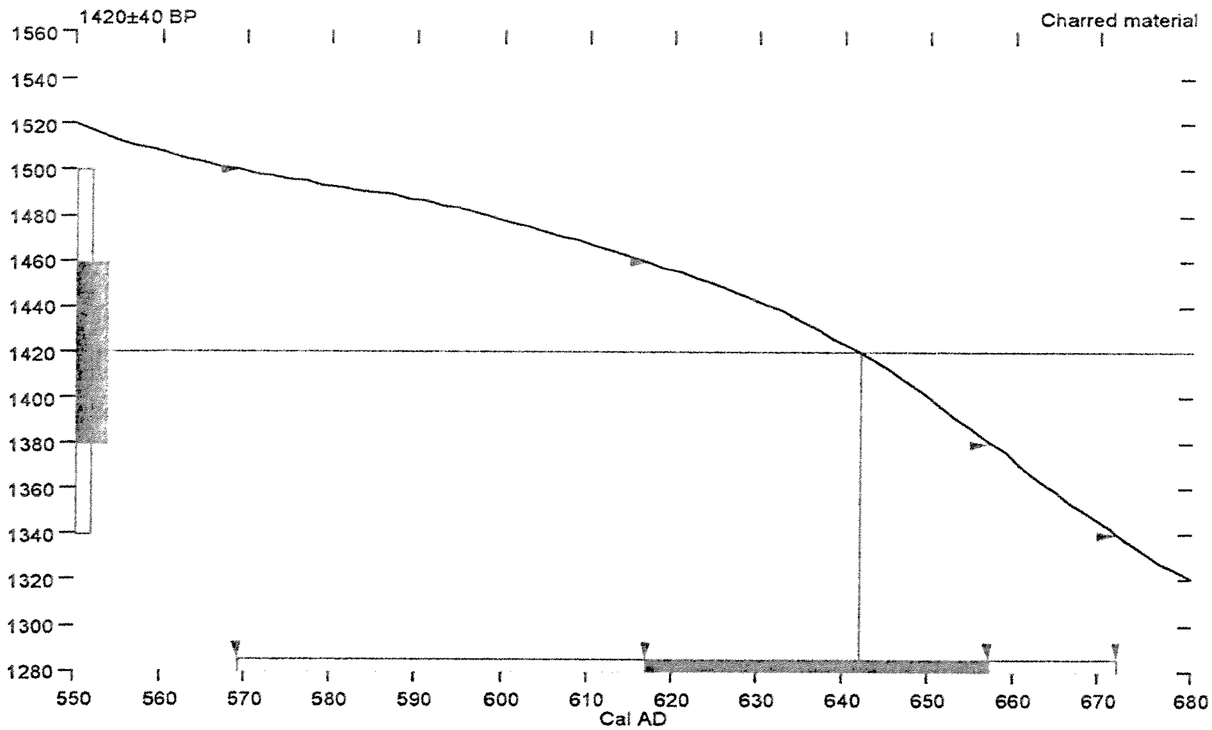
Conventional radiocarbon age: **1420±40 BP**

2 Sigma calibrated result: (95% probability) **Cal AD 570 to 670 (Cal BP 1380 to 1280)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 640 (Cal BP 1310)

1 Sigma calibrated result: (68% probability) Cal AD 615 to 655 (Cal BP 1335 to 1295)



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Calibration Database
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APPENDIX B

Flotation Analysis and Results

ANALYSIS OF TWO FLOTATION SAMPLES FROM THE GUADALUPE CORRIOR, SAN JOSE, CALIFORNIA

Brian Gassner
Anthropological Studies Center
Sonoma State University
Rohnert Park, CA 94928

Introduction

Two samples from the Guadalupe Corridor were processed using an IDOT manual flotation system to separate the charred botanicals from the soil matrix (see *Field and Laboratory Methods*). The two samples were designated as "Airport Parkway" (East-central segment, Trench 10-6-2, 290-300 cm), and "Fuel Farm" (CA-SCL-828, Trench 10-4-3, 240-280 cm). Both samples were composed of heavy, clayey soil. Warm water and a mild detergent were used in the flotation tank to facilitate the separation of botanical material from the soil. Even so, the flotation process did not achieve a good standard of separation, as indicated by the recovery of only 50% of the poppy seeds added to the "Airport Parkway" sample to test the rate of recovery. The samples were air-dried then sorted using a binocular microscope at a magnification of 8x to 50x. Both the heavy and light fractions were carefully sorted, and only charred materials removed from the samples. No attempt was made to identify species of wood present, however, the Fuel Farm charcoal was composed of predominately small, angular pieces that lacked identifiable morphology, while the Airport Parkway charcoal was composed of small, well-preserved twigs with only a few angular pieces. This difference may be partly a function of the flotation process, because the Fuel Farm matrix was probably more fragmented by the flotation process than the Airport Parkway matrix.

Airport Parkway

This sample produced little identifiable botanical material. Between the light and heavy fractions, 2.0 g of woody charcoal was recovered. The sample produced 0.17 g of charcoal for every liter of processed soil, and 1 seed was recovered for every 2 grams of charcoal. A single example of what appears to be *Polyganum* (Dock or Knotweed) was identified in this sample from the <0.5-mm split of the light fraction.

Fuel Farm (CA-SCL-828)

The "Fuel Farm" sample contained slightly more material than the Airport Parkway sample. The sample produced 0.33 g of charcoal for each liter of processed soil, and 3 seeds for every 0.4 g of recovered charcoal. Roughly 0.5 g of charred seed remains were recovered from the sample. Fragments *of Umbellularia californica* nut, or California Laural (bay) were identified in the > 0.5-mm split of the light fraction. Combined the three small fragments of bay nut weighed less than 0.1 g. Three seeds were tentatively identified as belonging to the Poaceae family, with only one whole specimen represented. The remaining charred botanicals were too fragmentary to identify to family or species, however, one of the specimens is clearly an attachment disk of an unidentified fruit or nut, and the other is an unidentified seed fragment.

Conclusion

The small amount of material recovered from the two samples does not readily lend itself to meaningful interpretations. While the presence of bay nut fragments and the unidentified attachment disk in the Fuel Farm sample might open a discussion about human habitation at SCL-828, they are little more than curiosities without a larger sample for comparison. However, the recovery of charcoal and seeds remains from these samples indicates the presence of certain plants that may be useful for paleoenvironmental reconstruction, and the presence of datable organic materials that may be used to determine the age of the associated deposits.

APPENDIX C

Pollen Analysis and Results

EXAMINATION OF SEDIMENT SAMPLES FOR POLLEN CONTENT, GUADALUPE PARKWAY PROJECT, SAN JOSE, CALIFORNIA

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Introduction

At the request of Jack Meyer, Project Geoarchaeologist, three Late Pleistocene/Early Holocene samples were examined for their pollen content. The samples were obtained from two locations (Airport Parkway and Taylor Street) within the Highway 87 corridor along the Guadalupe River, San Jose, California. The goal of the pollen analysis was to obtain paleoenvironmental data on the vegetation during the poorly understood transition from the Late Pleistocene to the Holocene for cismountane California.

Sample Provenience

Three samples, collected from geological exploration trenches, were submitted for analysis. (Sample number refers to the pollen extraction run number.)

Sample 1: Central Segment, Airport Parkway area, Trench 10-6-2, 290-300 cm, Unit II, 5Cub (Late Pleistocene alluvium)

Sample 2: Southeast Segment, Taylor Street area, Trench 10-7-1, 440-450 cm, Unit II, 5Ab (Early Holocene soil))

Sample 3: Southeast Segment, Taylor Street area, Trench 10-7-1, 470-480 cm, Unit I, 6Ab (Late Pleistocene soil")

Methods

Standard chemically based palynological extraction procedures were used to examine the sediment samples for their pollen content. To minimize the larger inorganic fraction, each sample was swirled and screened using the methods outlined in Mehringer (1967). Tablets with exotic *Lycopodium* spores were added to each sample as a check on processing methods and to determine pollen concentration values (Stockmarr 1971). A fraction of each processed sample was mounted on a slide and scanned with a Nikon microscope with Köhler and phase contrast illumination.

Results

Sample #2 contained a few pollen grains; the other samples did not contain pollen. The identifiable pollen grains in sample #2 were from members of the Asteraceae (sunflower family) and *Pinus* (pine) genera. Unfortunately there was not a sufficient number of grains present to recover a statistically meaningful count that could be used for comparative analysis. The Asteraceae grains are undoubtedly locally derived and the two pine grains could be from upland trees, since pine pollen grains can be readily transported long distances by wind.

References

Mehringer, Peter J. Jr., 1967 *Pollen Analysis of the Tule Springs site area, Nevada.* Nevada State Museum, Anthropological Papers, No. 13, pp. 131-200.

Stockmarr, Jens, 1971 *Tablets with spores used in absolute pollen analysis.* Pollen and Spores, Vol. 8, No. 4, pp. 614-621.

APPENDIX D

Probable Mission Locations

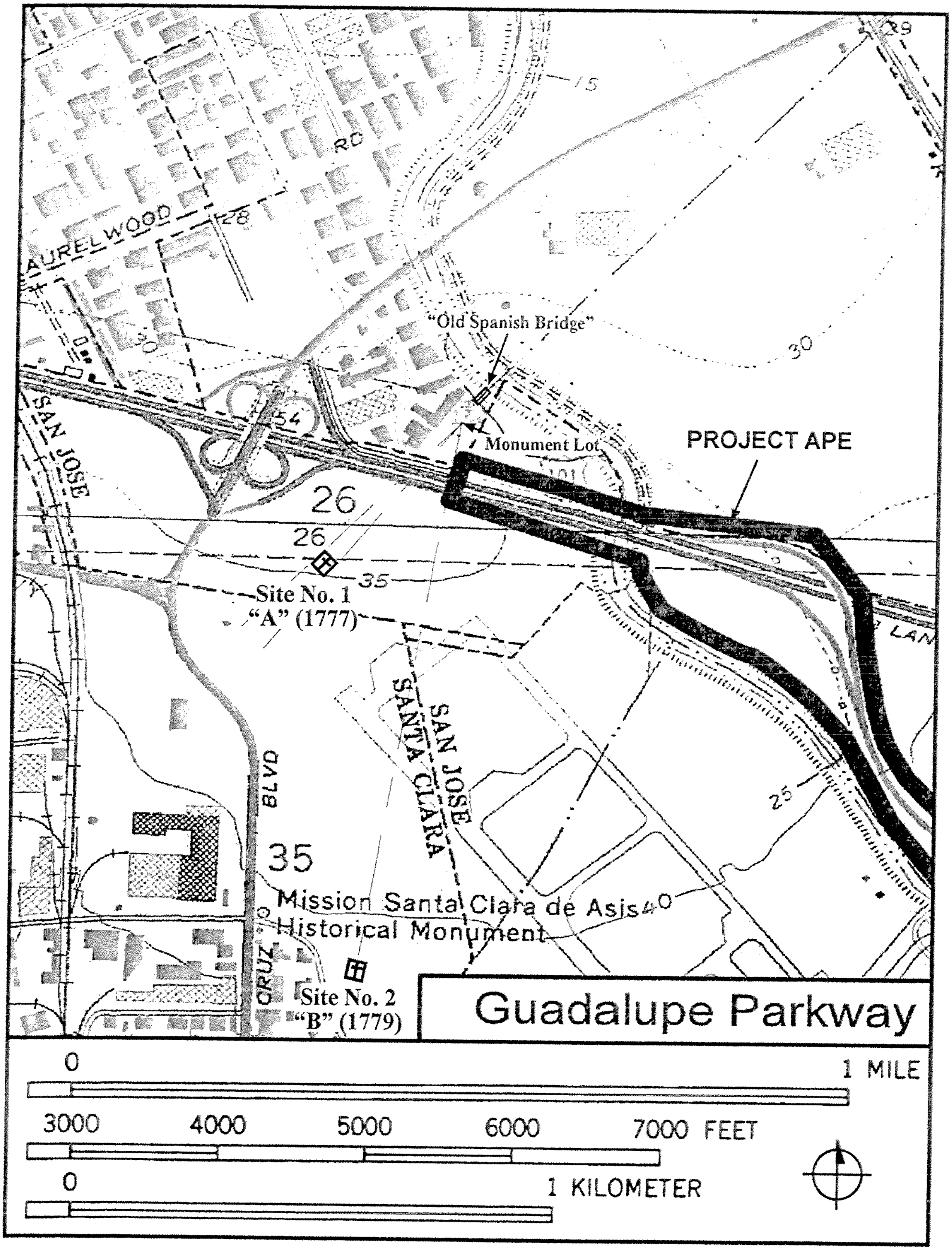

FIGURE A. Probable Locations of First and Second Sites of Mission Santa Clara and Old Spanish Bridge (adapted from Spearman 1963). Possible errors in location equal approximately +/- 50 feet (15.2 meters).

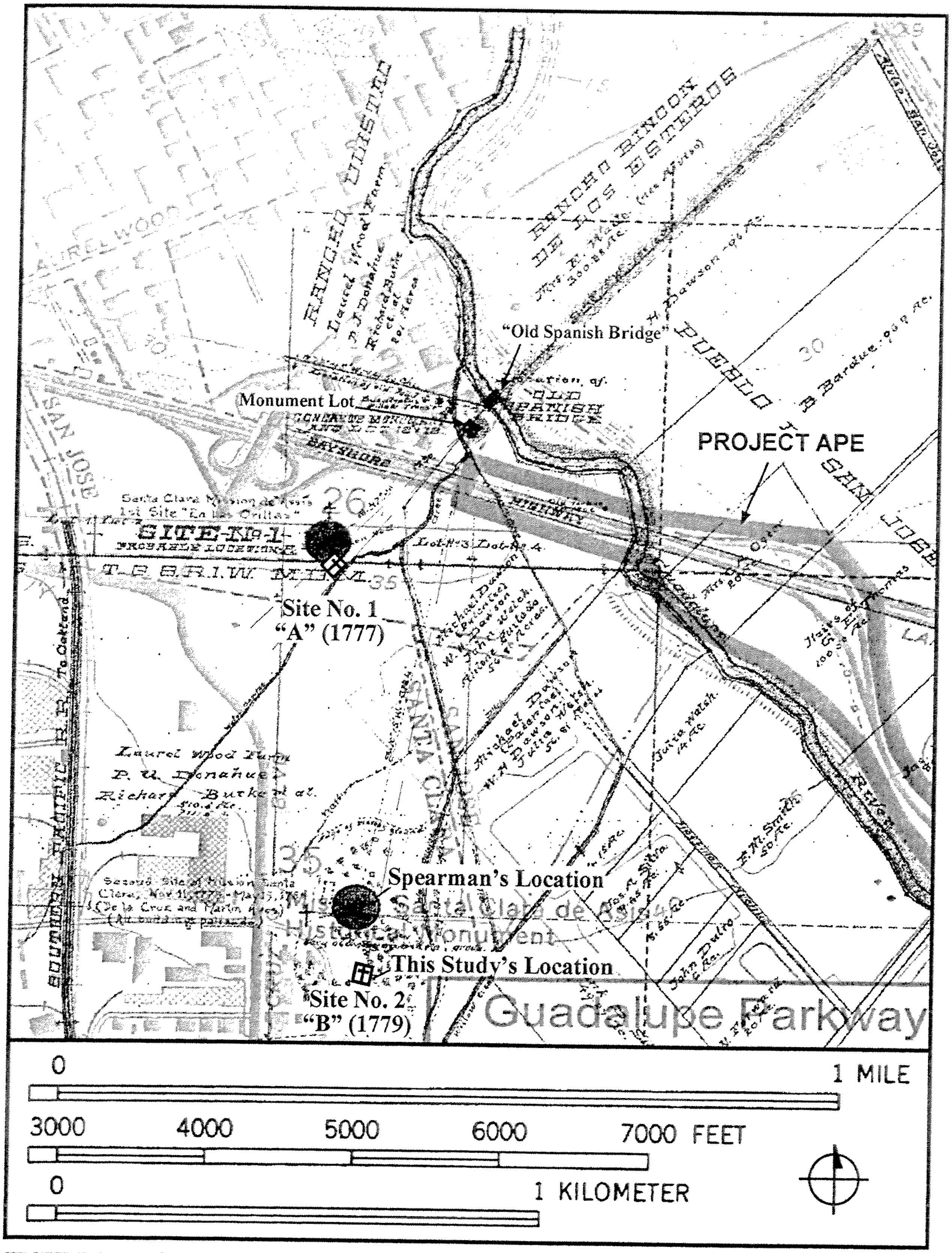

FIGURE B. Probable Locations of First and Second Mission Santa Clara Sites and Old Spanish Bridge Compared to Spearman's Map (1963:129) and Modern Map. Note locations of former river and creek channels. Possible errors in location equal approximately +/- 50 feet (15.2 meters).